Description of the Plate.

Figure 1 was drawn December 12, 1913. The central meridian is 252°, the central parallel +9°, and the diameter 14″.2. The solar longitude ☉ is 5°.6, and the martian date March 12. Seeing 8.

Figure 2 was drawn January 6, 1914. The central meridian is 351°, the central parallel +4°, and the diameter 15″.0. The solar longitude ☉ is 17°.6, and the martian date March 36. Seeing 8.

In both cases the water from the melting snow of the northern polar cap is seen stretching towards the equator. The shading in Figure 1 indicates the sunset terminator. The canals drawn were too narrow to show any color clearly. The south polar regions give the effect of a grassy plain. The yellow areas in Figure 2 are the martian clouds. These lie along the sunrise terminator, following the blue Acidalium Mare, and are also found at the south pole and stretching towards the equator along the limb. They shift about from night to night, and sometimes from hour to hour. The drawing was made one day after opposition, and the unusual circumstance will be noted that the northern limb is slightly darker than the terminator, in accordance with a note attached to the original observation. The nature of the brown area is unknown. Its color naturally suggests plowed fields, and it most likely is due to bare ground free of vegetation. The original drawings when completed were illumined by a tungsten lamp, and the colors were then found satisfactory when compared with the planet. The desert regions as here shown are somewhat redder than in the originals, in order to partially compensate for the redness of the tungsten filament as compared to sunlight. They are about the color that they appear when Mars is viewed in the daytime. It is probable that their real color is slightly redder. The other colors, which would be but little affected by the color of the source of light, are as near like the original paintings as they can be made.

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MYSTERIES OF MATTER.

JOHN CANDEE DEAN.

In the study of the vast, or of the minute, the imagination is incapable of comprehending the spaces involved. When we say that the sun is more than a million times larger than the earth, the statement does not present a mental picture of the sun's magnitude. A better conception of the sun's immensity can be obtained by saying that if the earth were placed in the center of a spherical shell, with a diameter equal to that of the sun, the moon's orbit would be a little more than half way between the earth and the shell of the sphere. But sizes of all things are relative. The magnitude of the sun is insignificant compared with some of the fixed stars. Professor Kapteyn estimates that the red star Antares, in the heart of the Scorpion, is 3400 times as brilliant as the sun. The diameter of Antares is estimated to be 160 million miles, or nearly as great as the orbit of the earth.

We meet with the same difficulties in attempting to comprehend the spaces occupied by molecules, atoms and electrons. Lord Kelvin said that if we could magnify a drop of water to the size of the earth, the atoms then might appear to be somewhat smaller than cricket balls. The average atom has been estimated to be 100,000 times as large as the electron. Now to bring the electron up to the size of Kelvin's magnified atoms, it would be necessary to magnify a drop of water to 100,000 times the size of the earth.

For nearly one hundred years Dalton's atom kept its place in the theory of the structure of matter. This atom was supposed to be the ultimate particle of matter, and stability was believed to be an essential characteristic of all the elements. At the beginning of the present century, the old theory of the indivisible atom, and of the stability of the elements, was upset by the discovery that certain rare elements were disintegrating, and changing, by throwing off particles much smaller than atoms. It must not be assumed that this discovery

demolishes the atom. It does not. The atom continues to be the unit that enters into all chemical combinations. The hydrogen atom was formerly the smallest particle known to science. Now the smallest particle known to science is the electron, whose weight is one seventeen-hundredth part of the hydrogen atom.

Herbert Spencer said, in substance, that organic progress consists in a change from the homogeneous to the heterogeneous, and this law of progress is the law of all progress. He said, "From the earliest traceable cosmical changes, down to the latest results of civilization, we shall find that the transformation of the homogeneous into the heterogeneous is that in which progress consists." No two elements have atoms of the same size or weight, and each of the different elements has strong individual characteristics. Atoms are therefore heterogeneous, and according to Spencer's law they must have been evolved from a lower stage of matter. Now electrons appear to be absolutely homogeneous, since all electrons are of the same weight or mass, carry the same electric charge, and always turn out to be the same thing, regardless of the metal that forms the negative electrode, or the gas from which they are derived. Hence, according to the Spencerian law, they should be the primal substance from which matter is evolved.

Stability is no longer regarded as an essential characteristic of the elements. The element radium disintegrates by the explosion of its atoms. The primary elements subject to disintegration by atomic explosions are uranium, actinium, and thorium. Radium is derived from uranium in consequence of its throwing off three atoms of helium. Hydrogen (1.008), is the lightest of the elements. Uranium is the heaviest. Its atom is 238.5 times as heavy as hydrogen. The atomic weight of helium is 4. Three atoms of helium would be 12, hence uranium (238.5) − helium (12) = radium (226.5). The atomic weight of radium is 226.4. The small difference is probably due to the loss of electrons during the change. Radium disintegrates by the breaking up of its atoms, each radium atom hurling off one atom of helium, and one of niton. The change is as follows: Radium (226.4) − helium (4) = niton (222.4). Therefore, the atomic weight of niton is 222.4.

The explosion of the atoms of radium appears to be as complete as that of a steam boiler; the whole of the atom bursts into gases. The light atoms of helium, that form, are shot into space with a velocity of more than 10,000 miles a second and the heavy residual atoms of niton acquire sufficient velocity, in consequence of the ejection of the helium, to escape and be deposited on bodies in the neighborhood. The expelled helium atoms are called Alpha rays. There is an inexpensive little instrument, called the Spinthariscope, which is arranged with a minute particle of radium in front of a zinc sulphide screen. On looking into

the instrument one can see the helium atoms bombarding the screen, each atom producing a minute scintillation, the hundreds of points of light making the screen sparkle like the stars in the Milky Way. The helium atoms are so minute that the bombardment of the screen could go on for hundreds of years without any sensible diminution of the particle of radium.

Radium also emits powerful Beta rays, which consist of electrons flying out with a velocity of 100,000 miles a second, capable of penetrating thin plates of metal. A third radiation, called Gamma rays, originate in the impact of the Beta rays. They are really X-rays of such strength that shadow-graphs can be made with them through eight inches of solid lead. This radiating power is an automatic property which cannot be produced artificially. Radium is a very heavy metal. Heavier than gold, mercury, lead, or any material with which we are familiar. It disintegrates very slowly. Its half period of decay is 1760 years. If a gram of radium were put away for 1760 years, only half a gram would remain at the end of that time; in 3500 years one fourth gram, and in 7000 years one eighth gram would remain. The half period of uranium is roughly estimated at seven billion years, while that of thorium, another radio-active element, at ten billion years. An attempt has been made to estimate the age of the earth from these slowly decaying elements.

As already stated the emanation of radium is niton, an inert substance which forms no salts. Niton's half period of decay is only four days, and its emanation is changed to a new type of matter called Radium A. Each second, a definite fraction of the number of atoms present break up, and the process of degeneration continues through a number of distinct unstable forms, called Radium A. B. C. D. E. F. Radium F is also called Polonium, an intensely radio-active substance with an atomic weight of 210.4. By throwing off one atom of helium its weight changes to a substance with an atomic weight of 206.4 which is close to that of lead, hence it is probable that lead is the final product of the radium series. Twenty-six so-called elements are derived from the automatic breaking up of uranium, thorium and actinium; sixteen of which are formed by throwing off of helium atoms, and are therefore real elements. Ten are formed by the emission of electrons and therefore are allotropes or pseudo-elements. It is by the ejection of full-sized atoms that substances of different chemical properties and valency result. We frequently have our attention drawn to the enormous energy stored in radium and its emanations. Sir Wm. Ramsay states that the heat which niton parts with during its disintegration is equal to 3,500,000 times the energy available by the explosion of an equal volume of detonating gas. The principal part of this

energy comes from the expulsion of helium atoms. He also says: "If radium were to evolve its stored-up energy at the same rate that gun-cotton does, we would have an undreamed of explosive, provided always that a sufficient supply of radium were forthcoming," and Sir J. J. Thomson startles us with the statement that the atomic energy stored in an ounce of chlorine, "Is about the amount of work required to keep the *Mauritania* going at full speed for a week." He further tells us that to split up an atom of one element into different kinds of atoms, would involve enormous transformations of energy, "In fact the explosion of the atoms in a few pounds of material, might be sufficient to shatter a continent."

The electromagnetic unit is an electric current of one ampere flowing for ten seconds. A sixteen candle-power, 110 volt, carbon-filament, electric lamp requires a current of one-half ampere. Therefore, such a lamp consumes one electromagnetic unit in 20 seconds. The agitation produced by the crowding together of millions of swiftly passing electrons gives rise to the brilliant light of the filament. The electric energy is so concentrated in the electrons that a mass of them equivalent to a mass of *one ounce* would light 300 of these lamps, to their full candle-power, night and day for a year.

In spite of the minuteness of atoms Rutherford has been able to detect the presence of a single atom of helium. He employed a partially exhausted vessel having a tiny hole, through which, by ingenious apparatus, single atoms of helium were shot. These atoms are expelled from radium with a velocity of more than 10,000 miles a second, striking and breaking up the gaseous molecules in the vessel, producing positively and negatively charged ions, which for an instant permit a current of electricity to pass. A current measuring instrument in the line records the entrance of the atom, enabling the observer to count each one as it enters.

We appear to be getting back to Franklin's single fluid theory of electricity. The electric current is believed to be a movement of negative electrons through a conductor, from the negative to the positive, instead of flowing from the positive to the negative, as was formerly supposed. Many scientists believe that negative electricity is the only kind. Positive electricity arises from a lack of electrons. For example, a positively charged helium atom is merely a helium atom that has temporarily lost two of its electrons. In theory the negative electron is not a particle negatively charged, but is in itself a negative charge. This is equivalent to saying that matter is wholly electrical. The electron enters into the structure of the atom, but is the weight of the atom due entirely to the mass of the electron? It is claimed that the electron has no mass in itself. Its apparent weight

is due to the adhering ether which it drags along, as it shoots through space. It is like stirring a bucket of water with a cane, a small quantity of the fluid will temporarily adhere to the cane and he carried along with it.

Nature is more marvelous, more interesting, and more beautiful than anything that the imagination can produce. The great French astronomer and scientist Henri Poincaré tells us that the scientist does not study nature because it is useful. He studies it because it pleases him, and it pleases him because it is beautiful. He says, "Were nature not beautiful, she would not be worth knowing, life would not be worth living. I do not mean here, of course, that beauty which impresses the senses, the beauty of qualities and appearances; not that I despise it—far from it; but that has naught to do with science; I mean that subtler beauty of the harmonious order of the parts which pure intellect appreciates."

It is a mistake to suppose that knowledge of breaking up of atoms into smaller particles originated with the discovery of radium. As far back as 1873 Sir Norman Lockyer suggested that many difficulties of the laboratory would vanish if we conceded that atoms could be broken up into much smaller particles. In 1890 he published "Inorganic Evolution as Studied by Spectral Analysis," in which he says, "Science now has to consider masses much smaller than the atom of hydrogen." In the study of the hottest stars he found himself in the presence of furnaces of transcendental temperature shielded by their vastness from the distracting phenomena which were present in the laboratory.

He classified the fixed stars in the order of their temperatures. Stars of the hottest class he called Argonian from the star Gamma of the constellation of Argo Navis, which has a temperature estimated by him at 50,000 degrees F. Gamma Argus contained a set of spectral lines not before recognized and he concluded that they indicated a new element connected with hydrogen. He called the new element proto-hydrogen, because of the relation of its lines to those of the proto-metallic lines. The Argonian stars are now called helium stars; they show but few element. Proto-hydrogen, helium, asterium, and proto-calcium are conspicuous. Lockyer tells us that the high temperature at which proto-hydrogen appears, is not the end of the simplification of stellar transcendental temperature. "The work of the dissociation of the atom carried on under our eyes in the hottest stars, is quite impossible in our laboratories." He says, "At higher temperatures the chemical units with which we work, at low temperatures, are broken up into smaller masses, explains the spectral phenomena observed, not only in our laboratories, but in the sun and stars." "The final breaking up by heat must be the earliest chemical forms."

Heat is a motion of the atoms of matter, and a fall of temperature slows down this motion, but man's ingenuity has not yet brought a single atom to a state of rest. The temperature of a body varies as the square of the amplitude of vibration of its atoms. If all the heat of a body could be abstracted its atoms would cease to vibrate. Increase of heat accelerates atomic motion until a critical velocity is attained that overthrows the affinities which hold the atoms in chemical combinations. At a temperature of 4000 F, the existence of water is no longer possible, not even in the form of steam. Its molecules no longer cohere, because of their energetic motion, and they dissociate into hydrogen and oxygen gases.

The heat of the sun is probably sufficient to dissociate all chemical combinations, consequently interior solar matter is in its monatomic, or elementary condition, and much of it may be in the electronic state. Perhaps there is a critical, or maximum temperature for all matter, where the violence of the motion of clashing atoms causes them to break up into electrons. In stars of the highest temperature like Gamma Argus, or Zeta Puppis, the critical state has probably been reached and the greater part of their matter is in the form of electrons. When matter is in its hottest state, it is at its lowest point in the scale of evolution, and progress depends on a fall of temperature by radiation. Lockyer's inorganic evolution, joined to the nebular hypothesis, and this to geological and biological evolution, completes the evolutionary cycle of matter to its present terrestrial stage.

We now come to the most interesting, most marvelous mystery of matter. There has been collected a wealth of evidence which proves that the atom is an organized planetary system of dazzling complexity, in which electrons simulate the movements of the planets of our solar system. The negative electrons of the atom swing around the positive nucleus, like planets around the sun. The planet Neptune requires 165 years for a single revolution around the sun, but it has not made a half revolution since its discovery, while the electrons of the atom complete their revolutions around their central nucleus in a millionth or a billionth of a second. The electrons revolve in a series of concentric orbits all in the same plane. While the larger part of the mass appears to reside in the nucleus; the nucleus is relatively minute, with a diameter of probably less than 1/5000 of that of an atom. It is thought that the simpler atoms, such as hydrogen, nebulium and protofluorine, where the electrons are few, all revolve in one ring, but in the heavier and more complex atoms, their orbits lie in three to five, or more rings. The atom is as much a machine as an electric motor and both are electro-magnetic engines.

Nearly the whole mass of the atom resides in the nucleus, but the nucleus is relatively very minute, It is quite impossible to imagine the extreme density of the nuclei. If an oxygen nucleus could be enlarged to a diameter of one inch, its mass would probably be more than 500 tons. If oxygen gas, at atmosphere pressure, could be magnified until the nuclei were each equal to the mass of the sun, we would have the sidereal universe reproduced in which the mean distance between atoms would approximate the mean distance between the fixed stars of the universe. Since the atomic weight of oxygen is sixteen, the atom is supposed to have eight electrons revolving around its nucleus. If we apply the same analogy of magnification to the structure of the oxygen atom, we would have a system of eight satellites in which the relative distances between the revolving electrons and the central nucleus would approximate the distances of the eight planets from the sun. Thus, in oxygen gas, the sidereal universe, with its stars and revolving planets is reproduced in miniature.

It will be seen that the structure of gases counterfeit on a very small scale, the structure of the great sidereal universe. Since all the forces acting in the nuclear atom are electrical, may not the forces acting in the stellar universe be electrical? Is not the force of universal gravitation electrical? Should not the universality of law lead us to infer that the force of gravitation is an electro-magnetic force?

It will be seen from the preceding description that the form of the atom is that of a flat disk, which probably possesses elasticity. It was formerly supposed that atoms were spheres of infinite hardness, and of course without elasticity. The atom, and in fact all matter, is immersed in a medium called ether, which is continuous, frictionless, and pervades all space. Ether is the universal carrier of the energy of light, heat, electricity and X-rays. Hydrogen has been called the smallest and lightest of the elements, but the sun, stars and nebulas yield still smaller atoms, called proto-hydrogen, asterium and nebulium. The atoms of these very primitive forms of matter are simpler in their arrangement, and easier to calculate than most terrestrial elements. Working in the dark, the alchemist of the Middle Ages attempted the transmutation of metals, without even knowing the nature of his problem. Science has now unveiled the secret of transmutation, by observing nature's process of changing the heaviest element into a series of different products. The alchemist vainly sought to change mercury into gold. We now know that mercury might be changed into gold, if we could expel from its atoms, one alpha particle, and a beta particle; or if the metal thallium could be made to expel an alpha particle, it would become like atoms of gold. This has not yet been done

but it is possible that it might be done by the application of an electric current of some million volts.

The principal weight of the atom lies in its nucleus, but the nucleus is very small compared with the size of the atom. It contains so-called "sub-atoms" and electrons, in association with positive electricity. The electric charge of the nucleus is therefore overwhelmingly positive. In the breaking up of atoms by radio-activity, the alpha particles, (helium atoms) and the beta particles (electrons) are thrown off from the nucleus. In the outer region of the atom there is a sufficient number of negative electrons to balance the central positive charge. It is this outer region that controls the chemical, and much of the physical influence of the atom. It will thus be seen that the radio-active charge is connected with the nucleus, while chemical and electro-chemical properties are controlled by the outer rings of electrons. It is now known that there are relatively few electrons revolving around the nucleus, probably not more than half of the number representing its atomic weight, in which hydrogen is the unit.

The period of revolution around the nucleus, by the electrons, appears to be identical with Kepler's harmonic law of planetary motion, in which electrical force, varying inversely as the square of the distance, takes the place of the force of gravitation. The lightest atom is supposed to have but one revolving electron. This limits the smallness of the atom, because you could not have an atom with no revolving electron. The smallest atom resembles the earth with its one satellite. The heavy atoms have far greater numbers; an atom of mercury would possess a hundred electrons, which is ten times as many satellites as Saturn has.

Lockyer has shown that the younger and hotter stars contain elements fewer in number, and simpler in structure, than the older and cooler stars. In this fact we face the gigantic evolution of matter from the primitive source of the universal ether, to the complexity of terrestrial organic matter. The mighty machinery of the cosmos is immortal in its operation. Ceaseless change is the only constant thing in nature. The complete cycle of change leads matter through all its phases from the simplicity of the hottest star to the complexity of matter in the planets and in our cool earth.

A recent article by O. Lehmann, on the discovery of the formation of liquid crystals, incidentally confirms the theory, that atoms are flat and not spherical. He assumes that the molecules of these crystals are tiny flat plates whose surfaces are perpendicular to the optical axis. He says, "The molecules easily glide over one another in a direction parallel to their flat surfaces," and concludes that the crystals are combinations of plate-like molecules. Since molecules are small groups

of atoms, and some molecules consist of single atoms, it follows that disk-shaped atoms would lend themselves to the formation of flat molecules.

It is probable that the atom is elastic; not perhaps by the pressure that could be secured artificially in the laboratory, but by the gigantic gravitational pressure of the interior of the planets and stars. The earth's interior is so hot that if its pressure were released it would explode into gases of very high temperature. The pressure of gravitation near the earth's center amounts to millions of pounds to the square inch, and there matter is reduced to the density of platinum. Under this force liquids yield like a sponge. Owing to the enormous pressure that gravitation imposes on the earth it is compacted into a dense mass as rigid as that of a ball made from nickel steel armor plate.

We now appear to be on the verge of further discoveries in the nature of matter which may lead to a knowledge of the mysterious, unknown, ether. All intelligent people are interested in new information regarding the swift electrons, that light our cities, propel our street-cars, operate factories, transmit speech, carry wireless messages and serve man in hundreds of ways. A host of eminent scientists have framed a science of radio-activity which has changed the entire theory of matter, involving conceptions that are difficult to explain to those who have not specialized in physical science. Even the accomplished physicist Sir William Crooke says that the conceptions of atomic physics are often hard to understand. We are unfortunately lacking in gifted interpreters of physical science, such as the nineteenth century furnished. Darwin, Huxley, Spencer, and Tyndal could clearly explain to the unitiated, in simple words, the most intricate scientific discoveries of their period.

Indianapolis, May 1, 1915.
University Club.

ASTRONOMY IN THE HIGH SCHOOL, VII. EXERCISES IN TESTING AND USING A SMALL TELESCOPE.

MARY E. BYRD.

All critical accounts of telescopic observations include some data about the instrument itself, and the smallest telescope, though rude and home made, if it can be used at all, deserves to be tested. First, however, comes the preliminary examination. This should be made in the daytime, when the different parts and the connection between them can be plainly seen. Then is the time to practice making adjustments, to bring a distant terrestrial object into the field, and find how the instrument inverts, that is, whether the image is turned partially, as in a mirror, or whether it is completely inverted, both up for down and right for left.

In order to obtain sharp, clear-cut images, special attention should be given to focusing. Never be satisfied with motion in one direction, but push the eyepiece in and draw it out, till the point of most distinct vision is passed in opposite directions, and then return quickly to that point. The double operation often seems superfluous to beginners, but pains must be taken to give the eye the best conditions possible, for its tendency is to adapt itself to whatever is offered, even when that involves strain.

As soon as convenient, there should be similar exercises in the evening with heavenly bodies. The moon and the Pleiades are satisfactory objects to employ in focusing and deciding about inversion. Note the connection between the latter, and the direction in which stars cross the field of view, and ascertain also whether the telescope, when carefully focussed, affects in like manner the size and brightness of both star and planet. When the more critical study is taken up, simple tests should be made regarding the following properties:

1. Light-gathering power.
2. Magnifying power.
3. Focal length.
4. Field of view.
5. Quality of objective.

To make the discussion of these topics definite, and if possible more vivid, a telescope with objective lenses 2½ inches in diameter has just been subjected to the various tests. The instrument used is one of the cheaper type, with tripod mounting, and motion only in altitude

and azimuth; and yet many years experience on the part of the writer leads to the conclusion that a telescope of this character is better adapted to the needs of beginners than those of finer workmanship which are far more expensive. In common with all telescopes of whatever size, it has two fundamental advantages; it brings more light to the eye, and makes objects appear nearer by magnifying them. It is at once evident that an objective of 2½ inches receives more light than the unaided eye, for the pupil of the eye has a diameter of only about $\frac{1}{5}$ of an inch; and the light falling on different circles varies as the squares of their diameters. If then L and L' represent respectively the quantity of light which reaches the object-glass and the eye, their relative amounts are given by the proportion:

$$L : L' :: (0.2)^2 : (2.5)^2, \therefore 0.04\ L' = 6.25\ L,$$
$$\text{or } L' = 156\ L.$$

Absorption, however, somewhat diminishes this amount, as even in a small telescope nearly $\frac{1}{5}$ of the light may be lost in passing through the lenses. Nevertheless, when this deduction has been made, the light obtained with the 2½-inch telescope, provided with suitable eye-piece, suffices to show more than two hundred thousand stars, while hardly seven thousand are visible to the unaided eye.

The magnifying power of a telescope depends upon the eye-piece, and may be found in several ways. Unfortunately the one that is especially adapted to inexperienced students is not included in elementary text-books. It consists simply in dividing the diameter of the object-glass by that of the objective opening which appears as a tiny circle of light, a little in front of the eye-piece. This, as is readily proved, is really equivalent to dividing the focal length of the objective by the focal length of the eyepiece (Chauvenet's Spherical and Practical Astronomy, Vol. II, Art. 13). The object-glass of a telescope must always be treated with scrupulous respect. No one in looking at it should allow even the breath to reach the glass, and certainly it is not safe for large numbers to undertake the measurement of its diameter. While it is well to make a few check tests with almost any scale, the value given by the manufacturer is usually sufficiently accurate; for a slight error in this diameter has little effect on the magnifying power obtained. With the emergent pencil of light the case is quite different. Its diameter should be determined as precisely as possible, within two or three thousandths of an inch.

According to the note-book record, which was kept in testing the instrument under consideration, a home-made scale with V-shaped opening was employed (Byrd's Laboratory Manual in Astronomy, §20). Measures were made by holding it near the eyepiece, moving it back and forth till the little circle of light appeared tangent to the inside

edges of the *V*, and noting the graduation marked above. Hundredths of an inch could be read directly, and halves or thirds were easily estimated. As is usual in making all measures required in astronomy, pains were taken to avoid errors. Thus, to guard against the tendency to obtain too large or too small values, the scale was held in two positions, horizontally and vertically, and motions to find the position for tangency were made in opposite directions, from the open to the closed part of the *V* and *vice versa*. To avoid bias in favor of a measure once taken, the graduations of the scale were covered with a strip of white paper, a dot marked at the point of tangency, and then its place fixed on the scale.

Following the preliminary statements about placing the telescope, adjustments for stellar focus, clearness of image, and similar details, the numerical record given in the notes for one date is,

		in.
S. H.,	*C* to *O*,	0.080
"	*O* " *C*,	0.080
S. V.,	*O* " *C*,	0.085
"	*C* " *O*,	0.080,

where *S.* stands for scale, *H.* and *V.* for horizontal and vertical positions, and *O.* and *C.* for open and closed parts of *V*. Like measures were taken on two other days, and the mean of the 12 gives the diameter of the circle of light as 0.081 inches. Therefore, the magnifying power is obtained by dividing 2.5 by 0.081 which gives 31. Since however, there is likely to be an error of as much as one diameter, even when careful measures are made with a good scale, the telescope is said to have a power of 30, with the particular eyepiece employed. That is, it shows Jupiter for example, with a diameter thirty times as great as that seen by the eye directly. This is a low power for a 2½-inch glass, but it brings the moon apparently within 8000 miles, which is much nearer than 239,000.

When, as here, the magnifying power is found independently of the focal length, no special advantage attaches to its precise determination, though it is well to know it approximately, since it is one of the properties taken as a standard in describing and comparing telescopes.

Its value was obtained thus:

After the eyepiece had been removed, a short steel scale was firmly attached to the draw tube, so that the part projecting below it was parallel to the axis of the telescope. The instrument was directed to the sun, and its image received on white cardboard, which was held in contact with the scale and at right angles to it. At the point where the sharpest image was seen, the readings on the scale were, $4\frac{6}{16}$, $4\frac{7}{16}$, $4\frac{8}{16}$ inches, making the mean 4.41 inches; and as the mean of three readings at the end of the draw tube is 3.25, the focal plane of the

objective is 1.16 inches in front of this tube. Finally, the mean distance from the center of the object-glass to the end of the draw tube was found to be 33.81 inches. Since hundredths of inches are retained during the work merely to ensure, as far as possible, accuracy in tenths the focal length is taken as 35.0 inches, a result which is probably trustworthy within two or three tenths, in spite of the fact that it is difficult to fix exactly the center of the objective, mounted as it is in its cell.

The field of view differs with different eyepieces. Its diameter, expressed in time, is the interval required for a star on the equator to pass centrally across the field. In making the actual determination, however, stars with high north declination are to be preferred. Those in the Little Dipper, called the Guardians of the Pole, were the ones employed. Both were observed near the meridian, β on two nights and γ on one. The moon on each night, being near first quarter, afforded satisfactory illumination for the field, but on account of its size and lack of spider threads, care was needed to obtain transits through the center. An Elgin watch with face lit up by a small lantern was used in recording, and the following times entered in the notes for the second star:

γ Urs. Min. enters field,	9^h	58^m	0^s
γ " " leaves " ,	10	9	38
Mean time watch interval,		11	38

This is reduced to a sidereal interval by adding two seconds, since for the degree of precision required here the gain of sidereal on mean solar time may be taken as 4 minutes a day, or 10 seconds an hour. To reduce $11^m\ 40^s$ to the equator, that is to find how long γ would have taken to cross the field had it been on the celestial equator, it is necessary to multiply by the star's declination, and as that is $72° 8'$, we have,

log cos δ,	9.4869
" 700,	2.8451
log 214.8,	2.3320

This value, $3^m\ 34^s.8$, combined with the two obtained from β Urs.Min., gives $3^m\ 33^s$ as the diameter of the field of view, when the eye-piece employed was that already found to have a power of 30. The same low power was used in making tests for the quality of the object-glass, upon which depends, in large measure, the efficiency of the telescope as a whole. It ought to show stars very nearly like points of light, and all images sharp and clear-cut without "wings of light" or extraneous color. In a home-made instrument, a wing of light is sometimes caused by inaccurate centering of the different lenses, but it usually indicates that all parts of the objective have not the same refracting power. Blurred images and those of variegated color indicate aberra-

tion. If there is spherical aberration, light from a single point in the object has not all been brought to the same point in the image. If there is chromatic aberration, light rays of different color are not all brought to the same focus.

In testing the refractive power and the achromatic character of the 2½-inch objective, the planet Jupiter was observed, when favorably placed, about half way from horizon to meridian. The sky was clear, but the air full of moisture from late rains, and the seeing only fair. When the planet was in the center of the field, and the eyepiece carefully focussed, no wings of light were seen nor extraneous color. The entire limb was sharply defined, and the three satellites visible appeared like points of light. As equal distinctness and freedom from protruding light were found in observing the new moon, it is fair to conclude that different parts of the objective have the same refractive power. With Jupiter in the field, when the eye-piece was pushed in beyond the point of distinct vision, a very narrow band of purple light was seen, extending nearly around the disk. It was most noticeable on the upper part of the limb, and wanting at the opposite point, just below. When the eyepiece was drawn out, there was no clearly marked color, rather a "muddy" white, with now and then a tinge of pale yellowish green at the lowest part of the disk. These results, confirmed by those obtained from the moon, when the seeing was good, indicate a faulty correction for chromatic observation. This is not uncommon with instruments of the cheaper type, but with low powers, for example, those below 70 with this instrument, the defect causes little inconvenience in actual observing.

As usual, stars were employed in making the test for spherical aberration. After η Boötis, a third magnitude star, had been brought into sharp focus, a cap was placed over the objective, covering half its diameter, but no change in adjustment was desired. A repetition of the test on another night with another star gave the same result, and thus it is evident that rays of light from the central and outer portions of the object-glass have been brought to the same focus, that is spherical aberration is satisfactorily corrected.

While it is not necessary to complete all the tests suggested before beginning to use the telescope, it is desirable to make some of them promptly. They help to give the training and the feeling of assurance which are needed in using the instrument to advantage.

In planning for observations, it is easy to make an ambitious program but it is better for beginners to have a short and very definite outline especially as the first study of the heavens should be carried on mainly with our own eyes. Their value as an astronomical instrument is all too easily overlooked in these days of celestial photography and the multi-

tude of optical appliances. But time is doubtless saved and better results obtained by those who come to the telescope with eyes already trained by many hours devoted to observing directly.

When evening work begins, no time is spent to better advantage than that given to ensuring a thoroughly satisfactory focus, placing objects in good position in the field, and learning how, by slight motions, to keep them there.

It is assumed, in the suggestions that follow, that the object-glass is not less than 1.5 inches in diameter, and that the magnifying powers of the eye-pieces are from 20 to 60. A statement regarding these points ought to be included in the notes on every observing evening, either explicitly or by reference to the record of some earlier date. As a matter of convenience, eye-pieces should be numbered and telescopes named, if more than one is used from time to time.

When practicable, the first object studied should be the moon, since that for the inexperienced worker with the telescope, takes precedence of all other heavenly bodies. One must be blind indeed to beauty who does not recognize the exquisite effects that it presents under low powers, and even a stronger attraction for the student lies in the fact that much can really be learned about it with a small, inexpensive glass.

It is well to choose the first evening when the phase is that of a slender crescent, for then the contrasts between light and shadow are most strongly marked, the terminator is most deeply serrated, and beyond appear the "isles of light". The second period is taken to advantage near first quarter when almost every characteristic feature is shown. Several of the "so-called" seas are prominent, two or more mountain chains stand out clearly, and crater mountains abound including some of those that are especially distinguished.

On the latter night a drawing should be made; and, while a lunar map is required in naming and identifying objects, not a little care must be taken to work independently in sketching at the telescope. The illuminated portion of the moon ought to be depicted, as nearly as possible, just as seen, with careful outlines of twenty or more of the most important markings.

The sun, unlike the moon, shows little detail with a small telescope. The few points to be noted, like those with opera-glasses, are the effect of the instrument on color and brightness, comparison of limb and center, and general surface appearance. If any spots are visible, several short periods should be given to them on different days, in order to find in what direction they are moving, and what changes take place in size, shape, and other features during a brief interval.

With any telescope, the solar disk may be studied from projections

on white cardboard, but direct views are more satisfactory; and, if the objective is less than three inches, the eyes can be properly protected by placing several pieces of colored glass in a cap covering the eye-piece. It is hardly safe, however, to trust to one piece, no matter how thick and dark.

For planets, nebulae, and stars, the following working-list is suggested as a guide in making their first acquaintance under magnifying power:

1. Examine Venus near inferior conjunction when it shows the crescent phase. Compare it then as regards form, size, and color with the new moon seen directly, without magnifying power.

2. See whether the telescope affects the color of Mars, and whether it shows a disk for the planet.

3. Observe Jupiter twice in the same evening, and make, each time, a diagram showing the position of the satellites. Describe the belts if they are visible.

4. Look at Saturn and note whether or not the appearance of the rings is like that which Galileo obtained with his telescope.

5. Examine the nebulæ of Andromeda and Orion and see how they differ in size, form, and brightness.

6. Describe the appearance of three of the following star-clusters:

The Pleiades: Præsepe in Cancer; Coma Berenicis; H, VI; 33, 34, near η Persei; M. 13, between η and ζ Herculis.

While making observations, keep in mind points like these:

(1) Difference between opera-glass and telescopic views.

(2) Density and form of cluster, and size in terms of the field of view.

(3) Approximate number of stars by count or estimate.

(4) Tendency to cluster in any noticeable way.

(5) Range in magnitude of stars and contrasts in color.

(7) Make a diagram of the telescopic field showing Mizar and Alcor, the neighboring eighth magnitude star, and the components of Mizar.

(8) Examine about half the double stars in the list below:

(1) ζ Ursæ Maj., *i.e.*, Mizar and Alcor.
(2) α Capricorni.
(3) ϵ Lyræ.
(4) β Lyræ.
(5) ν Draconis.
(6) δ Orionis.
(7) θ Orionis.
(8) β Cygni.
(9) 61 Cygni.
(10) ζ Piscium.
(11) θ Serpentis.
(12) ζ Ursæ Maj., *i.e.*, Mizar.
(13) α Geminorum.
(14) γ Virginis.

The examination of double stars should be made critically. Most of those taken from the list above ought to be compared with some one pair, serving as a standard, points of likeness and difference being noted. Here as elsewhere, the telescope in the hands of students ought not to be a toy for amusement, but a means to aid in revealing the unknown.

RECENT OBSERVATIONS OF THE NEBULAE AND THEIR BEARING UPON THE PROBLEM OF STELLAR EVOLUTION.

R. E. WILSON.

The last thirty years of spectrographic research have given us some fairly clear ideas as to the constitutions and motions of the stars during that period of their history in which they appear as points of light—when we say that their condition is stellar—a period covering presumably a large part of their total period of existence. Astronomers have no reason to doubt that all the heavenly bodies, stars, planets and nebulae, are of the same constitution, and are composed of the terrestrial elements, or substances from which these elements have developed. They are agreed also that the differences in the spectra of the stars are due chiefly to differences in temperature, which seem to be, for the most part, the direct result of condensation under the action of gravitation. The process by which a star passes through its various stages of development up to the time it becomes a dead, burnt-out, sun cannot be said to be so satisfactorily established, although on many points connected with this process astronomers are substantially agreed.

It is generally considered that a part, at least, of the process of stellar evolution is represented by an orderly sequence of stellar spectra, beginning with the Classes B and A, characterized principally by absorption lines of helium and hydrogen, passing by insensible gradations through Classes F, G and K, somewhat similar to the spectrum of our sun, to Classes M and N, spectra of the red stars, some of which are generally believed to represent the last stages of stellar development. This sequence was suggested by studies of the appearance, progression in intensity and disappearance of lines in stellar spectra, coupled with laboratory investigations as to the origin of these lines and their behaviour under different conditions. It has been borne out by many later investigations. For instance, it has been shown that the wave-lengths of many of the spectral lines, presumably blends

of two or more single lines, vary with spectral class and that this variation bears a direct relation to this sequence. The magnitude of the color index, the difference between the visual and photographic magnitudes, increases directly with it. The periods and eccentricities of spectroscopic binaries increase directly with it. Most important was the discovery that the average radial velocities of the stars of different spectral classes are not the same but that they increase directly with the sequence. This discovery was later extended to include the proper motions of a large number of stars and the real motions of a few stars with known parallaxes. So it is generally accepted that this spectral sequence must be one of the fundamental factors in any discussion of the processes of stellar evolution. The principal facts in connection with it are shown in Table I.

TABLE I

Spectrum	Ave. Radial Velocity	Color Index	Approx. Temp.
Class B	6.2 km.	−0.3	20,000°C.
A	10.5	0.0	11,000
F	14.4	+0.4	7,500
G	15.9	0.8	5,000
K	16.8	1.3	4,200
M	17.1	1.6	3,100
Md	29.	...	...
N	...	2.5	2,300

The interpretation of these results has given rise to two distinct theories of stellar evolution. Both postulate the development of stars from nebulae. The more generally accepted theory follows the sequence directly. According to it, the Class B stars are comparatively young. The position of a small group including the Wolf-Rayet and bright line helium stars is assuredly at the beginning of the sequence, as they are closely related to the Class B stars in many ways. Some of them contain superposed bright and dark lines and seem to be changing from bright-line to dark-line stars. So far as our limited knowledge of them goes, their radial velocities are systematically small. Stars of Classes A and N represent the successively more advanced stages of stellar development. With advancing time the visual radiations pass from the violet and blue to the prevailing yellow color of the Class K stars and then to the prevailing red color of Classes M and N. In these classes* "surface temperatures have lowered to the point of permitting more complicated chemical combinations than exist in the sun. In the extremely red stars, a large proportion of which are variable in brightness, we may be observing the first struggles to form crusts over the surfaces; for example, the several long period variable stars, whose

* Campbell, "*Stellar Motions*," page 37.

spectra at maximum brilliancy show bright lines of hydrogen and other elements. The hot gases and vapors responsible for the lines seem to be alternately imprisoned and released. It is further significant that the dull red stars are all very faint; all fainter than the sixth magnitude. Their radiating powers seem to be very low. The period of existence succeeding Classes M and N has illustrations near at hand apparently in Jupiter and the other planets of our Solar System, invisible save by borrowed light." It is easy to believe that there are as many if not more of these invisible bodies, burnt-out stars, in space as there are luminous suns. According to this theory it would appear that a star is born without motion and gradually acquires one, and that this motion gradually increases as the star grows older. Thus we have a tolerably satisfactory history of the stellar stage of stellar development. The principal objections to this theory arise from the postulate that the early class stars are formed from the nebulae. As the temperature of a nebula cannot be far from absolute zero, it is difficult to see how stars of Class B, with the highest known temperatures, may be formed without some intermediate stages. It will also be shown later that, while the average radial velocity of the extended nebulae is small, as would be required by the theory that a star is born without motion, that of the planetaries is larger than that of the oldest stars. Thirdly, this theory does not explain certain facts which have given rise to the second current theory of stellar evolution.

This theory is based upon the discovery of the existence in space of what are known as the "giant" and "dwarf" stars. Researches principally by Kapteyn and Hertzsprung, upon absolute stellar magnitudes, have shown that there are two classes of stars, one of great brightness, averaging about one hundred times that of the sun and varying little from one class of spectrum to another, the other of less brightness which falls off very rapidly with increasing redness. Russell has collected certain facts with regard to these stars which seem to be fairly well established. The differences in brightness between the "giant" and "dwarf" stars do not arise directly from differences in mass. The surface brightness of the stars diminishes rapidly with increasing redness. The mean density of the stars of Classes A and B is a little more than one-tenth that of the sun. The densities of the "dwarf" stars increase with increasing redness from this value through that of the sun to a limit which at present cannot be exactly defined. This increase in density together with the diminution in surface brightness accounts for the rapid fall in intrinsic or absolute luminosity with increasing redness in the stars. The mean densities of the "giant" stars diminish rapidly with increasing redness from one-tenth that of the sun in Class A to less than 1/20,000 in Class M. This counteracts

the change in surface brightness and explains the approximate equality in the luminosity of these stars. In order to explain these facts Russell suggests a modification of Lockyer's stellar classification based upon a scale of increasing densities with ascending and descending branches of the scale of temperatures, radial velocities, etc., somewhat as represented in Table II.

TABLE II.

Spectrum	Ave. Radial Velocity	Color Index	Temp.	Density
Class P	40 km.	...	low	low
M	17	1.6	3,100°C.	1/20,000 ⊙
K	17	1.3	4,200	...
G	16	0.8	5,000	...
F	14	0.4	7,500	...
A	10	0.0	11,000	1/10 ⊙
B	6	—0.3	20,000	1/10 ⊙
A	10	0.0	11,000	...
F	14	0.4	7,500	...
G	16	0.8	5,000	1
K	17	1.3	4,200	> ⊙
M	17	1.6	3,100	> ⊙
Md	29	...	...	...
N	...	2.5	2,300	...

According to this theory,* as the primordial nebula condenses its volume diminishes, its density and temperature increase until a very red star is formed of low density of the order of about 1/20,000 that of the sun, a "giant" star of Class M. With increasing condensation and consequent increase in density and temperature, the surface brightness increases rapidly, compensating for the loss in surface area by contraction, and we have successively the "giant" stars of Classes K, G, F, A and B. As condensation becomes slower, the loss by radiation begins to overpower the gain in energy by condensation. The temperature begins to fall and the star proceeds in the reverse order back through A to M. In this stage the density is increasing and both volume and surface brightness diminishing, hence the absolute magnitude diminishes rapidly and we have the "dwarf" stars of the later types. This theory clearly obviates the three strongest objections advanced against the first theory but it, in its turn, introduces some difficulties which are sufficient to prevent its ready acceptance among scientists. The main objections to this theory also arise from the postulate that stars develop from nebulae. Nebulous areas are never associated with stars of the "later" spectral classes. Between the gaseous nebulæ and the red stars there are few, if any, spectral resemblances and it is difficult to believe that the stars of Class M with continuous spectra, crossed by multitudes of absorption lines, could have

* Plaskett, *The Sidereal Universe*, *English Mechanic*, Apr. 23, 1915.

developed without some intermediate stages from gaseous nebulae, the spectra of which contain only a few bright lines. Inasmuch as the assumption that the stars are evolved from the nebulae seems to present the most prominent objections to the current theories of stellar evolution, it is of interest to consider the bearing of the recent observations of the nebula upon this question.

The nebulae may be divided into four classes; the "white" nebulae, both spiral and non-spiral, with spectra in general closely resembling Class G or Class K; and the planetary and extended, whose spectra consists chiefly of sharply defined monochromatic bright lines. It is a reasonable assumption that there are discoverable with a large telescope at least 500,000 of these objects and that more than half of them will be found to be spirals. The latter are distributed in a peculiar way over the celestial sphere, showing a marked tendency to avoid the Milky Way; the planetary and extended are rarely found far from the Galactic plane. Nebulous areas are always associated with stars of Classes O, B and A, but never with Classes G, K, M or N. When we see early class stars, such as those composing the Pleiades or a large part of the constellation of Orion, surrounded by and apparently involved in extended nebulous areas, we can scarcely doubt that we have circumstantial evidence at least that here we have stars in the making and that the extended nebulae should take their place in the scheme of stellar evolution before the Class O and B stars.

Most of the nebulae are exceedingly faint and spectrographic observation of them very difficult. With the instruments in use for the observations of the stars only a few of them could be effectively observed. Almost the only radial velocities of nebulae secured prior to 1911 were those of thirteen planetaries and the nebula in Orion determined by Keeler with a visual spectroscope attached to the Lick refractor. He found that the average velocity of the planetary nebulæ was about 26 km per second while the Orion nebula was almost at rest in space. These results were interesting but they were too few to give them much weight in the discussion of the problem of stellar evolution.

Since 1911 new cameras have been designed by Campbell at the Lick Observatory and Slipher at the Lowell for the observation of these objects, the guiding principal of the design being to increase the intensities of the spectra falling upon the photographic plates and thus to shorten exposures. This has brought perhaps two hundred more objects within the reach of spectrographic observation, with exposures of practicable lengths.

During the past three years, at the Lick and D. O. Mills Observatories, observations of ninety-two extended and planetary nebulæ have been

secured. The velocities of the extended nebulæ are habitually small and appear to conform to the view that these objects represent a stage of stellar evolution preceding the slowly moving Class B stars. The average velocity of the planetary nebulae, however, is also confirmatory of the early results of Keeler, for it proves to be about 40 km per second, excluding those in the Magellanic Clouds which seem to fall in a class by themselves, or nearly seven times the average velocity of the Class B stars with which these nebulae were supposed to be directly related. If our criterion in the first theory of stellar evolution, that a star has no initial velocity but acquires one with increasing age, be true we should place the planetary nebulae at the other end of the sequence following the fast moving red stars.

The observations of Wright, at the Lick Observatory, have established beyond question a direct relation between the planetary nebulae and the Wolf-Rayet stars. One of the most interesting of the Wolf-Rayet stars, DM. + 30°3639, was found by Campbell to be surrounded by a glowing hydrogen envelope. Palmer and Stebbins found the well-known nebular line λ 3727 in its spectrum and Merrill later found two others in the red region. Last year Wright made several exposures of two nights duration upon this star. These plates recorded all the brighter nebular lines except λλ 3869 and 4363 in addition to the lines of hydrogen and helium, showing conclusively that the so-called hydrogen envelope is in reality a planetary nebula. A long exposure upon the nebula NGC 6572 with very accurate guiding isolated the spectrum of the nucleus as a narrow band of continuous spectrum showing five Wolf-Rayet bands. The nucleus was thus established as a Wolf-Rayet star. In three other cases of nebular nuclei of which the Lick Observatory has spectrograms the nucleus is undoubtedly a Wolf-Rayet star. In still another case, in the spectrum of the nucleus of the planetary nebula NGC 2392, the hydrogen and helium lines are dark; the spectrum is that of an Oe star, the class immediately preceding Class B. Wright concludes that, "there is no escaping the conclusion that the nuclei of planetary nebulæ not only are closely related to Wolf-Rayet stars but that in many cases they are such stars."

Working upon certain assumptions as to the constitution of the atom, the English physicist, Nicholson, has produced mathematically a theory of the evolution of the elements, and his computations of the wave-lengths of the principal lines in the spectra of the gaseous nebulæ and the early-class stars give results in close agreement with the observed positions of these lines. His work seems to establish theoretically a definite connection between these nebulæ and stars. These two investigations, one purely observational, the other purely theoretical, form a strong argument for the first theory of stellar evolution, namely,

that the stars of classes O and B are the direct product of the condensation of the gaseous nebulae without the intermediate stages of red and yellow stars.

Campbell finds an apparent explanation of the high velocities of the planetary nebulæ in the behaviour of the so-called *novae*, or new stars. "The best explanation of these stars is that they are due to the rushing of dark or relatively faint stars through invisible nebulæ or resisting media. The resulting collisions, in effect a bombardment of the stellar surfaces, seems to generate sufficient heat to convert the surface strata of the stars into incandescent gases and vapors. Spectrographic observations have shown for all recent *novae* that, in the course of a few weeks or months, the spectra of the *novae* are converted into nebular type. Later the nebular spectra disappear and a certain type of stellar spectrum takes their place. These changes seem to occur rapidly, perhaps because the bombardments have been but skin deep. That planetary nebulae may have resulted in some such way from the collisions of stars and resisting media seems quite possible. Exactly those stars which are traveling with very high speeds would have the greatest chance to encounter resisting media; and, further, the disturbance would be deeper and more permanent the higher the speed of collision. Conversely, if this speculation has a basis in fact, that is, if the planetary nebulae have been formed in this manner, the prevailing high velocities would find a natural explanation."

It has also been suggested, in view of the comparative number of planetary nebulæ and *novae* and their similar distribution within or near to the Milky Way, and especially in view of the fact that the *novae* often show Wolf-Rayet bands just prior to entering upon the nebular stage, that the planetaries are wrecks of ancient *novae*. This suggestion is not out of harmony with the views just expressed either as to the formations of the planetary nebulæ or their position in the scheme of stellar evolution. The position of the planetary and extended nebulae in the scheme of stellar evolution, therefore, seems to be fairly well established. However they may be formed or whatever their velocities, there can be little doubt that they represent a stage immediately preceding the stars of the earlier spectral types.

Spectrograms of about fifteen spiral nebulae have been obtained by Slipher at the Lowell Observatory. The spectra shown by them were predominantly solar type and the velocities determined were unexpectedly large. The eleven for which Slipher gives definite values are as follows;

N.G.C. 221	— 300 km per second	N.G.C. 4565	+1000 km per second
224	— 300	4594	+1100
1023	+ 200	4736	+ 200
1068	+1100	5866	+ 600
3115	+ 400	7331	+ 300
3627	+ 500		

Three of them have velocities equal to or greater than 1000 km per second away from us, while only the four which are not tabulated have velocities of less than 200 km per second. The average is about 400 km per second. We can have no conception of a large body such as a nebula rushing through space with such an enormous velocity. If these observations actually represent the radial velocities of these nebulæ, their total space velocities must be of the order of 800 km per second and it is difficult to believe that they can have any intimate connection with our general stellar system.

The probability that the spiral nebulæ are independent and isolated universes has been suggested many times. Their distribution on the celestial sphere is radically different from that of the stars and gaseous nebulae. They show no direct relations with single stars nor spectral affinities with the gaseous nebulæ. The little we know of their spectra seems to indicate that they are integrated spectra. Recent work upon stellar motions has established the existence within our system of two star streams, such as would be expected if our system had been evolved from a two-branched spiral. Modern researches upon the extent of our system indicate that it has a diameter of from 10,000 to 15,000 light years and a thickness of from 2,000 to 3,000. The total space motion of the spiral nebula cannot, in all cases, be directly towards or away from us. We can account for the lack of proper motions and parallaxes large enough to be observed, in combination with the large radial velocities, only upon the ground that the spiral nebulæ are very distant. The order of the distance of those nearest to us may be indicated by Hertzsprung's estimate of the distance of the Smaller Magellanic Cloud as 30,000 light years, assuming that space is transparent. This would put them well without the limits of our system.

So far as the writer knows, the remaining class of nebulae, the white, non-spiral, with continuous spectra, have not been systematically observed. Accepting the connection between the gaseous nebulae and the early type stars as established, Plaskett suggests that this may be the exception rather than the rule and that, in general, the first stage of stellar evolution may be exemplified in these much more numerous white nebulae or in some invisible to us and that from them the process of evolution may follow the order laid down by Russell in the second theory. This suggestion is not without the bounds of possibility and it will be of interest and importance to secure observations of as many of these white nebulae as possible.

The observations of the Magellanic Clouds may throw some light upon the question of stellar evolution. They show many resemblances to the Milky Way which is the basis of our stellar system. Just as the Milky Way may be described as a great compound cluster made up of

innumerable subordinate clusters, so the Magellanic Clouds seem to be gigantic nebulæ embracing and bringing into some kind of correlation multitudes of separate nebulæ. They consist of large tracts of irresolvable nebulæ and of nebulosity in all stages of evolution up to perfectly resolved stars, of gaseous and non-gaseous nebulæ, as well as clusters in every stage of resolvability. The Greater Cloud contains some 278 nebular objects, nineteen of which are known to be gaseous. The Smaller contains but one gaseous nebula. In the two Clouds we find undoubted stars and undoubted nebulae at the same general distance from us. The planetary nebulæ and the Wolf-Rayet stars appear to be confined in their distribution to the Milky Way, with the exception of those found in the Magellanic Clouds.

Observations at the D. O. Mills Observatory have shown that the twelve nebulæ observed in the Greater Cloud are all moving away from us with speeds varying between 250 and 300 km per second the average being 277 km per second, while the one observed in the Smaller Cloud has a velocity in the same direction of 160 km per second. It is scarcely possible to doubt that these nebulæ are really within the structure of the Clouds, for there are no other known bright-line nebulæ surrounding or at all near them. While we still lack the observations of the faint stars within the Clouds necessary to show that the Clouds as a whole are moving with the observed velocities, it seems highly probable that the nebulæ and the general structure of the Magellanic Clouds are traveling together and receding from us with the enormous velocities of 277 km per second for the Greater Cloud and 160 km per second for the Smaller. In view of their resemblance in appearance to the spiral nebulæ, in view of their high velocities, comparable with those observed for the spiral nebulae, and in view of Hertzsprung's determination of the distance of the Smaller Cloud, it seems quite probable that the Magellanic Clouds are related to the spiral nebulæ, if indeed they are not actually great spiral nebulae, nearer to us than the others so that we can observe more of the details of their structure.

If the Magellanic Clouds are stellar systems outside and independent of our system and we find that the gaseous and non-gaseous nebulæ exist together as component parts of these systems, the presumption of evidence, at least, favors the view that the white nebulæ of non-spiral formation will be found to be members of our system and, as such, should play some part in the process of stellar evolution. What that part may be we have not yet evidence enough to determine, but Plaskett's suggestion that they represent a stage preliminary to development following the second evolutionary theory does not seem to lie without the bounds of possibilily.

The results of the recent observations of the nebulæ may be summed up as follows: a definite relation has been established between the planetary nebulæ and the Wolf-Rayet stars; the average velocities of the extended nebulæ have been found to be small, and those of the planetaries large; these nebulae seem to play definite parts in the process of stellar development; the average velocities of the spiral nebulæ and the gaseous nebulæ in the Magellanic Clouds have been shown to be so large as practically to preclude the possibility of their membership in our stellar system. These results constitute a great advance over our knowledge of five years ago but they leave much to be desired in our study of stellar evolution. Among the more important *desiderata* are more observations of the spiral nebulæ, observations of as many as possible of the white, non-spiral nebulae, and observations of the Wolf-Rayet and other faint stars in the Magellanic Clouds, to determine whether or not the velocities derived from the gaseous nebulæ are representative of the Clouds as a whole.

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THE EARLY BABYLONIAN COSMOLOGY.

HECTOR MACPHERSON, M. A., F. R. A. S.

From the earliest ages the human mind has been confronted by the great questions presented by the natural world—the earth—its nature and origin—and the outer universe—its structure and origin. The name of the first actual student of nature must remain forever in obscurity. It is tolerably clear, however, that astronomy is the oldest branch of science, because the heavenly bodies are the most prominent of natural objects. The early students of nature must have noted the phases of the moon and the fact that the starry skies presented different aspects at different seasons. Later men must have observed that the sun itself did not remain fixed in position, but varied in its altitude above the horizon.

Probably this kind of knowledge grew up in various countries simultaneously. There are traditions of early astronomers and astrologers in China, in India, in Egypt and in Babylon; for early astronomy was inextricably mixed up with astrology and religious ceremonial and thus the priests of the ancient religions were in many cases the pioneers of astronomical observation.

An observant study of nature, however, is almost invariably accompanied by what is called a cosmology or world-concept. The mind of man, even in primitive conditions, is not content with mere appearances; it desires to know things as they are, and to penetrate behind the veil of appearances. The human mind ever seeks a world-concept. Thus, even in very primitive times, men formulated theories of the natural order and of the relation of the earth, our dwelling-place to the outside world as a whole.

Every ancient people has its cosmology, or concept of the order of the world, and accompanying this, its cosmogony or theory of the world's origin. That these early ideas were crude and fantastic is not to be wondered at; they are interesting as illustrating the first gropings of humanity after an explanation of the mystery of being.

Among early peoples, as the late Professor Pfleiderer points out, "cosmogony is at the same time theogony". We might also say that cosmology is at the same time theology, for if not quite identical, the two were inextricably connected. To the ancients nature was full of deities. There were gods of land and sea, gods of sun and stars, gods of storm and tempest. Both religion and service were born of a crude cosmo-theology, largely the product of wonder and fear—wonder at the marvels of external nature and fear at its caprices and vagaries.

The closeness of the connection between early cosmology and theology is obvious when we consider the influence of climate on early religious cults. We find the sidereal cult in countries like Babylonia, India and Egypt, where the skies are clear and the brilliant stars force themselves on the attention of mankind. In the words of Professor Cumont, "Every sidereal cult, properly so-called, was originally foreign to the Greeks as to the Romans—a fact which undoubtedly proves that the common ancestors of the Italians and the Hellenes dwelt in a northern land, where the stars were frequently concealed by fogs or obscured by clouds. For them nearly all the constellations remained a nameless and chaotic mass and the planets were not distinguished from the other stars. Even the sun and moon, although they were regarded as divinities, like all the powers of nature, occupied but a very secondary place in the Greek religion."

In Babylonia, as in Egypt and India, science and religion were almost inextricably mixed, fused in a popular mythology. As Pfleiderer points out, "Among the eastern Semites of Mesopotamia, the Babylonians, or Chaldeans and Assyrians, the old Semitic star-worship was mixed up with the more naturalistic beliefs of the original inhabitants of the land, now generally distinguished by the name of Accadians or Sumerians. From the intermixture proceeded alike the mythology, the *cultus* and the art of the Babylonians."

In the old animistic worship, animals, plants and stones, rain, winds and storms were regarded as divine, while the Semites worshipped the stars, which they were thus compelled to study closely. The Babylonian priest-astronomers devoted themselves first of all to the measurement of time and the distinction of the planets and the stars. On a tablet, dated 539, is to be found the relative positions of sun and moon, calculated in advance. The conjunctions of the moon and planets and of the planets among themselves, and the zodiacal positions of moon and planets are noted with their exact dates. These planetary bodies were always in some way or other associated with the divinities whom the priests worshipped.

In the Babylonian system of divinities, the five gods of the planets were combined with two triads of deities, which correspond with the upper world, the middle world and the under world. Above all, supreme over the other gods, was the Lord of Lords, the "Bel Beli," who was also known as "Ilu," "the god." The star gods were also prominent in the local cultus of the town of Babel. These were Naba (Mercury), the god of revelation and priestly wisdom; Nergal (Mars) the god of war; Merodach (Jupiter) the lucky or propitious star; and Istar or Bilit, the Hellenic Venus, goddess of fertility and also of death.

From this connection between planets and gods arose the Babylonian system of astrology. Of all natural objects, the Babylonians ascribed a chief influence to the stars. This is not to be wondered at, for the stars in the clear air of Syria and Mesopotamia shine with a brilliance quite unknown in western lands. The brilliant stars and the even more brilliant and at the same time mysterious "planets," or wanderers, filled these oriental peoples with a sense of superstitious awe. Hence arose the astrology of the Babylonians. The priestly astronomers became pre-eminently astrologers. As Schiaparelli truly remarks, "the tendency which dominates the whole Babylonian astronomy as to discover all that is periodic in celestial phenomena and to reduce it to a numerical expression in such a manner as to be able to predict its repetition in the future. Hence, astrology and religion remained in the closest union among the Babylonians. Theology and cosmology—and therefore theogony and cosmogony—were closely intermixed.

The Babylonian cosmology consists of speculations as to (1) the present state of the world and (2) how the world came to be.

In regard to the constitution of the world, the Babylonian conception did not differ much from those of other primitive peoples. The heaven was believed to be a solid vault, whose foundations rested on "the deep" (âpsu), on which the earth also rested. Higher than the vault of heaven were the "upper waters" while higher still was the dwelling of the gods "the interior of the heavens." From this celestial house

the sun emerged through a door in the morning and into the same house he passed in the evening, through another door. The earth itself was supposed to be a huge mountain, of which the under portion was hollow. In the east is the mountain of sunrise and in the west the corresponding mountain of sunset, while in the north is an unknown and mysterious country. Inside the earth, above the hollow central portions, is the abode of the dead, the entrance into which lies towards the west. Finally between the vault of heaven and the crust of the earth are the waters of the eastern and western ocean, which, along with the southern ocean, form part of the deep or the "âpsu".

The conception of the deep played a very important part not only in Babylonian cosmology proper, but in cosmogony as well. The culture of primitive Babylonia, as Professor Sayce has pointed out, radiated from two chief centers, the sanctuary of Nippur in the north and the seaport of Eridu in the south. The former was an inland sanctuary, while the latter was on the coast, and, as Sayce remarks "what I may term the geographical setting of the two streams of culture varied accordingly." The great temple at Nippur was known as "Ê-kur," the "house of the mountain land" while Eridu was the home of Ea, the "god of the deep." In the cosmogony of Eridu, water was the origin and source of all things. The solid earth itself was believed to have sprung from the deep. The deep, however—subject to the scheme of things presided over by the gods of light—was no mere chaos in which there was no law. "Chaos," it is true, was the designation of a lawless realm. But the conception of the "chaos of Timiat" belongs, in the opinion of Sayce, to the cosmogony of Nippur. "The world of Nippur was a world from which the sea was excluded; it was a world of plain and mountain and of the hollow depths which lay beneath the surface of the earth...The earth and not the water would have been the first in order of existence...In the chaos of Timiat accordingly, I see the relics of a cosmology which emanated from Nippur and was accepted wherever the influence of Nippur prevailed." The two conceptions, so obviously antagonistic, belong to separate schools of thought. They were destined to become considerably modified in the course of time. Merodach was the god of the city of Babylon and he took the place of Ea as the creator. The early cosmology of Nippur was afterwards blended with that of Eridu and as a result, again to quote Sayce, "there are two creations, the first chaotic, the second that of the present world."

The Babylonian Epic of Creation, which has attracted so much attention in recent years on account of its similarity, real or supposed, to the creation story in the Book of Genesis, is a combination of these two legends by a much later writer. First there is a struggle between

Timiat, the dragon of darkness and Merodach, the god of light, resulting in the victory of the latter and symbolizing the triumph of the forces of order over chaos, of creation over the void, of law over anarchy. The victory over chaos was only the beginning of creation. The gods of the triad—Anu, Bel and Ea,—were given particular positions in the heavens. Next comes the creation by Merodach of the heavenly bodies.

"He prepared the stations of the great gods;
The stars corresponding to them he established as constellations.
He made known the year and marked out the signs of the zodiac.
Three stars he assigned to each of the twelve months.
From the beginning of the year till its close
.....
He made the moon appear, illuminating the night."

Generally, it was believed that the account of the creation of the heavenly bodies was followed by an account of the creation of the animal world, but Zimmern thinks that it belongs to another story, in which not Merodach but "the gods" collectively exercised the functions of creation.

Another account of the creation was discovered by an English scholar, Mr. Pinches. This legend which is believed to go back to Sumerian times, emanated from the temple at Eridu and is less complicated than the Epic of Creation. It has certain points of resemblance to the second account of the creation in Genesis; in another fragment the analogy is still more striking. The story is distinctly parallel to the Biblical account of Adam and the Fall.

The Epic of Creation itself is a comparatively late production. It is the final word of Babylonian thought on the origin of things and is distinguished by the three principles underlying the cosmology and cosmogony of Babylonia. These were:—(1) The belief in water as the primal element, (2) The conception of a lawless chaos from which the world has been rescued as a result of the conflict of light and darkness and (3) The conception of generation as the chief creative force.

Interesting in itself, the Babylonian cosmology is still more interesting when viewed in relation to the Hebrew cosmology and the early philosophic conceptions of Greece. Widely as the Hebrew and Greek races differed in their essential characteristics, widely different as were the ultimate forms of their cosmological speculations, they both betray affinities to the Babylonian world-view. Whether the creation story in Genesis is derived from the Babylonian account or whether both are derived from an earlier document does not concern us here; but the similarity between the two is by no means accidental. On the other hand Babylonian thought exercised a great influence on early Greek speculation. Thales, the founder of Greek philosophy, fixed on water as the primary substance of the Universe. From Babylonian science, then, Greek and Hebrew thought drew a certain degree of inspiration.

RESULTS OF METEOR OBSERVATIONS FOR JULY AND AUGUST, 1915.

CHARLES P. OLIVIER.

In response to the request for volunteer observers to take part in the work of the American Meteor Society, during the past two months not less than one hundred people have written asking for maps, information etc., most of them signifying their intention of observing in accordance with the plans outlined in the various articles published on the subject. Added to those who had already joined, at least nominally, this makes a total of about one hundred and twenty-five persons who are interested in the systematic study of meteors. During the past two weeks, the reports for July and August have been coming in and this present paper gives a brief summary of what was actually done in those months.

Altogether 21 people, observing in 14 states and one in Canada, reported. The following table gives the results:

TABLE I

Observer	Station	No. Nights	No. Meteors
S. W. Balch	Montclair, N. J.	5	29
J. L. Bedford	Watertown, N. Y.	4	134
Mrs. Grace Bessey	Pensacola, Fla.	7	245
Mrs. L. C. Brubaker	Hunter's Valley, Calif.	1	17
F. J. Carr	Swanton, Vt.	3	82
C. S. Cole	Ogontz, Pa.	2	75
R. M. Dole	Raleigh, N. C.	1	111
Alfred Doolittle	Washington, D. C.	3	23
Howard Eaton	Madison, Wis.	2	46
F. C. Hamer	Staunton, Va.	2	54
R. C. Lamb	Franklin, Ky.	4	134
Raymand Lambert	Newark, N. J.	3	75
John Larkin	Croton-on-Hudson, N. Y.	3	64
Lincoln LaPaz	Wichita, Kan.	5	150
F. C. Leonard	University, Va.	2	30
Miss Doris Lifferton	Lachine, Quebec.	3	39
Miss Helen Merriam and assistants	Hartford, Conn.	1	50
C. P. Olivier	University, Va.	7	363
D. E. Procter	St. Louis, Mo.	8	49
T. McN. Simpson	Richmond, Va.	2	35
J. Brookes Smith	Hampden Sidney, Va.	3	86
Total: 21 observers.			1891

Some words of explanation are necessary. It must not be supposd that because a person sent only a small number of meteors, that his results are not of value and that he did not attempt observations on

other nights. Particularly for the observers in the Southern States, there was very much cloudy weather in August, which prevented extensive observations in many cases. Other reports are no doubt en route, or will arrive in the near future. Many of the observers also had various obstacles to overcome during their first attempts which will be removed in future work, since they now understand more clearly by actual experience just what is wanted.

One piece of work of exceptional importance was planned and the results are now being worked out. This consisted of simultaneous observations on August 9 to 13 inclusive, from 12^h to 14^h E. S. T. at four stations as follows: Professor Alfred Doolittle, Catholic University, Washington, D. C., Professor T. McN. Simpson, Richmond, Va., Professor J. Brookes Smith, Hampden Sidney College, Va., and C. P. Olivier, University of Virginia, Va.

The comparison of our results show quite a number of apparent coincidences and indeed the real heights for some of the meteors have actually been computed already. Not only did the other three observers mentioned do their part in the observing, but they are also doing some of the computing. The actual results will form part of a future paper.

The society has been most fortunate in having Mr. R. M. Dole, of the U. S. Weather Bureau, join in its work. Mr. Dole has already observed over 5000 meteors and these he has kindly agreed to have worked up completely and published by the society. All astronomers will recognize the great value of this contribution—one of the largest single ones ever made by any observer.

In addition to the above there are 2500 other observations made by members during 1914 and 1915, which are still unpublished. It will be seen therefore that the next publication of results will be a very considerable one. Work on its preparation has already begun, but from the great amount of data to be discussed, it will naturally be some time before it can be published. In it every member, who has contributed anything, will have the fullest recognition given his work.

It is hoped that this most encouraging report will arouse the real interest of those who have done nothing as yet, and encourage those herein mentioned to even more successful efforts. Again we extend a cordial invitation to anyone interested and will be glad to furnish bulletins and maps on application.

Leander McCormick Observatory,
University of Virginia.
Sept. 17, 1915.

PLATE XXIV.

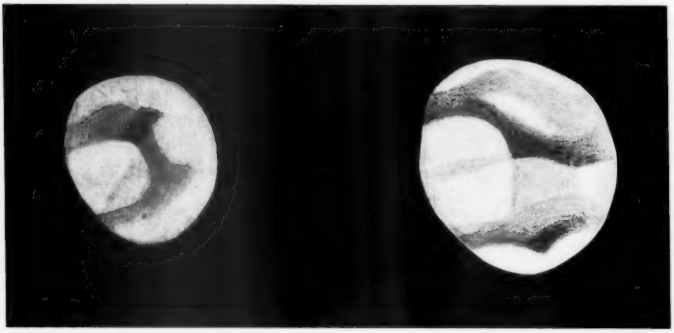

FIG. 1
1913 September 17
Martian Date, January 39
36° 7″.8

FIG. 2
1913 October 30
Martian Date February 27
346° 10″.3

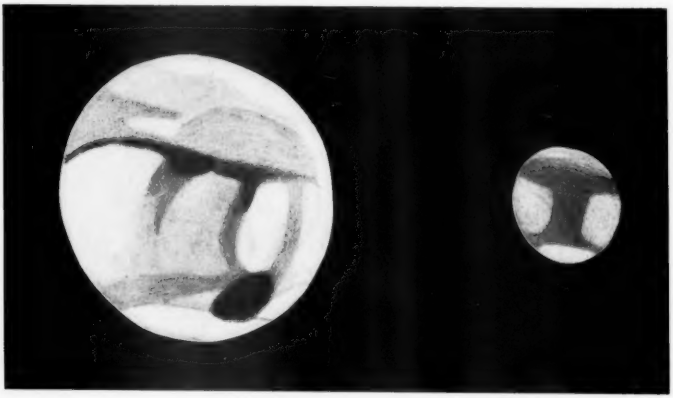

FIG. 3
1913 November 30
Martian Date February 55
0° 13″.1

FIG. 4
1915 August 27
Martian Date February 5
63° 5″.3

DRAWINGS OF MARS.

REPORT ON MARS, No. 11.

WILLIAM H. PICKERING.

Drawings of Mars.

At the close of the coming opposition it is proposed to publish a series of drawings similar to those which appeared in Report No. 8, with the idea of giving to future astronomers the best idea possible of the appearance that the planet presented in 1916. Several well known observers have already promised to send drawings, but as it is possible that some one unknown to the writer may now be capable of producing work of the highest merit, it has been decided to invite not only all of the Associated Observers of Mars, but also all others who may be interested in the project, and who think they are obtaining results more or less comparable to those published in Report No. 8, to send their drawings to the writer, and the best series will be published. Drawings made with a less aperture than five inches will not be likely to show enough detail to be accepted for this purpose. Those interested should carefully read Report No. 8, and study particularly Table 1.

Six drawings are to be sent by each competitor. The central meridians should coincide as closely as possible with longitudes 0°, 60°, 120° 180°, 240°, and 300°. The drawings must be carefully finished, and should measure 3 inches (76mm) in diameter. Each of the original sketches on which the drawings are based must be finished at a single setting, and *no details, canals or lakes inserted on the drawing that are not seen that same night.* This is important, since a complete change in some particular detail may occur within twenty-four hours, and two canals for instance that are never seen at the same time, might thus apear on the same drawing. In each case the date, the times of beginning and ending, the aperture, magnification, and seeing should all be recorded. The observers' initials should be placed upon the back. The drawings should be made between January 10 and March 10, 1916, and all must be mailed to the writer before April 1, addressed Harvard Astronomical Station, Mandeville, Jamaica, B. W. I.

Those drawings not published will be returned at the request of the sender. Since a certain amount of contrast is always lost in publication, allowance should be made for this fact. Indeed, light pencil markings are not shown at all in a reproduction. If it is not possible to obtain a complete set of six drawings, all that are obtained should

nevertheless be sent, since the whole or portions of the set may still be published, if they are exceptionally good. These drawings it will be noted are *quite independent* of those to be sent regularly by the Associated Observers, which are for study, and which will not in general be published.

Observers are particularly cautioned not to try to see too many canals. Don't insert any of which you are not perfectly sure. It is better to leave out three real canals than to put in one that isn't there. Difficult features are always uncertain, and their delineation is of doubtful value. What we lay stress on is that the obvious features should be drawn correctly. These features are subject at times to marked changes, and it is believed that these changes are of more interest and importance in solving the economic problems of life on the planet than anything else observed upon it. It is because they are so marked, so very much more so in fact than anything that occurs upon the earth, or indeed elsewhere in the universe, as far as our telescopic powers carry us, that Mars has for us such an absorbing interest.

The quality of a drawing therefore will not be determined to any great extent by the number of canals shown upon it, indeed too many canals will certainly count against it. On the other hand unless a certain number are clearly seen by the observer it is of no use to send the drawings. The width of those canals shown is considered to be a matter of considerable importance. The qualification pre-eminently sought however is accuracy of the coarser detail. Dividing the canals and lakes on any given competing set of drawings into three classes (a) those that most of the individually invited observers see, (b) those that a few of them see, and (c) those that none of them see, we may express the method of qualification of the competing drawings mathematically, somewhat as follows:—

Let the quality and accuracy of the drawings of the coarser detail of the competing set, as judged by comparison with the work of the individually invited observers, be represented by Q, then the qualification of the competing set will equal $Q + Aa + Bb + Cc$, where A, B, and C are constants for all the competing sets. Let us make A equal 1, and give B a small positive, and C a large negative value. A high positive value of the combined second and fourth terms will then indicate that a drawing resembles a composite of those furnished by the individually invited observers, while a high value of the third term will place a premium on any improvement shown by the competitor. We may determine the value of C by making the second and fourth terms neutralize one another for the mean of the individually invited observers, that is C will equal $-\frac{Aa}{c}$. It then merely remains for us to

exercise our judgment as to what values to attach to *Q* and *B*.

The chief object of this proposed competition however is not simply to publish the best set of drawings of Mars, but rather to determine the names of several observers working under favorable conditions in different portions of the world, and having the facilities and capacity for doing the best work, and that most suitable for publication. It is desirable that these names should be discovered at as early a date as possible, and it is therefore hoped that no one will be too modest to send in his drawings, even if he is not one of the Associated Observers. There are indeed so few well known observers of Mars, that he should consider it his duty either to publish his drawings himself, or else to make himself known in this manner, whether his drawings are published or not.

It is a debatable question whether the point of Aryn, within the forked bay of Sabaeus, appeared at all at the last opposition. There is good evidence on both sides of the question. It has been pointed out by Lau, *A. N.* 1915, **200**, 44, that according to the observations of Schiaparelli in 1886 and Comas Sola in 1900-01, that at aphelion oppositions Aryn is never well seen. Lau himself was unable to see it in 1914, but his telescope was rather too small to furnish reliable evidence on so delicate a question. All observers are requested to record the date this winter on which it is first certainly visible to them.

Beginning of Observations.

The observations on Mars began this year at Jamaica on July 18. The aperture of the telescope is 11 inches (28 cm) and the magnification unless otherwise stated 660. The solar longitude ☉ as seen from the planet was 310°.7 and the corresponding Martian date on the new calendar (see Report No. 10) January 22. The longitude of the central meridian ω was 90°, the latitude of the center −7°, and the declination of the sun as seen from the planet −18°. The diameter corrected from the ephemeris to that employed in 1914 (see Report No. 10) was but 4″.8. In order to avoid repetition, these data for all of the observations will be found collected in Table I.

The detail observed was insignificant and uncertain, consisting simply of a suspected dark area in the southern hemisphere. In spite of the Martian date, January 22, there was no snow visible near the northern pole of the planet, nor even any brightening due to cloud. Yet on this date the sun reached within 18° of the pole, or to latitude 72 N. This however is not unusual. In 1913 the brightening was first detected on M. D. January 25, or three days later. Little detail indeed had been expected, the purpose of the observation being to test the new blue

source of illumination, and thus to determine the real color of the planet. A black paper mask with a hole eight millimeters in diameter placed on the record book gave a disk of the proper size.

Using a carbon filament of 2 candle power the correct distance of the light was found to be 9 inches, and the proper color for the paper that of yellow ochre. This was of interest since on three occasions in 1914, ⊙ 25°.1, 50°.6, and 62°.9, white paper itself was found to be too red (see Report No. 9). On substituting tungsten for the carbon filament the only change noted was that the color of the planet appeared redder, and was now best matched by a combination of yellow ochre and raw sienna. It matched in fact very closely the color represented in the illustrations of Report No. 10, which if viewed by a tungsten light should therefore give a very good idea of the appearance of the planet. The combination of blue glasses that had been found to give with tungsten the color of direct sunlight was next tried. This so far reduced the light, that to obtain the proper illumination a 5 c. p. lamp was substituted for the other. Even this had to be placed at a distance of but 2.5 inches from the paper. The effect on the color of the disk was striking. The yellow ochre and raw sienna no longer matched the planet, but we now had to use a sheet of paper colored by a combination of dragon's blood and Saturn red, which nearly matched a moderately dark brick. This then is the true color of the surface of Mars, and is not unlike that of the soil in some of our southern states.

In this connection it may be pointed out that by a species of color analysis, just as white indicates to us snow, yellowish white, cloud; blue, water; green, chlorophyl in vegetation; so red indicates oxygen in the form of iron oxides in the soil,—oxygen the source of all life and growth. There is indeed no compound abundant upon the earth other than an oxide that could give us that striking and characteristic red color. Were it needed, we thus have a strong indication of the presence of this necessary element in the crust of our sister planet.

The next observation was made August 27, corresponding to the revised Martian date of February 5. Central longitude 63°. The most conspicuous feature was the brightening near the north pole, which appeared to be due to cloud rather than snow. In 1913 on September 17 at ⊙320°.9, corresponding to the revised M.D. January 39(see Figure 1), a broad dark area 400 miles in width followed the course of the Ganges from the northern snow to the southern maria, its direction lying about 20° to the east of south (see Reports Nos. 1 and 2). By October 30, M. D. February 17, Figure 2, it had spread to the east as far as Sabaeus, and had thus broadened to a width of 1500 miles! It clearly connected the dark northern area due to the melting snow, which had already formed, with the southern maria where the vegetation was now developing.

Its first observer seems to have been Secchi, in 1858, who represented it at that time as curved, and less than 100 miles in width (Flammarion **1**, 138.) It was first seen fairly broad by Dr. Lowell and the writer at Flagstaff, in 1894 (Flammarion **2**, 130, 189). This time it appeared straight and 200 miles in width, but did not reach north of Lunae Lacus. It seems next to have been observed as a broad band by M. Jarry-Desloges in 1909 and 1911 (Observations des Surfaces Planetaires **2** Plates 6 and 7, **3** Plates 7 and 9). He represents it as straight, and reaching from the southern maria to the band surrounding the melting snows, but its breadth never exceeded 400 miles.

It would appear therefore to be a phenomenon of recent development as far as concerns its great size, and clearly one of considerable importance judged by that fact and by its conspicuous character. It probably only escaped general notice in 1913 because it presented itself so early in the season, before most observers had begun work on the planet. By November 30, 1913, ⊙ 359.9, M. D. February 55, Figure 3, it had largely faded out, but its eastern progress had been continued, and it reached from the eastern side of the forked bay of Sabaeus as far west as Margaritifer. It had also shifted its position angle from 20° east of south, to 20° west. To express these changes in another way, it may be said that it had shifted its northern end about one-third way around the polar cap, slowly draining the whole of that sector of the polar snows. It should be particularly noted that it shifted towards the geographical east, that is, to lower longitudes. The polar marshes all shifted towards the west.

As a recently developed Martian phenomenon it was of especial interest to look for it this year, although the planet would be very remote at the time. The favorable solar longitudes in 1913 extended as we have seen from 320°.9 to 359°.8, or practically to the vernal equinox. At the observation made this year, the longitude was 332°.9. With considerable interest therefore it was noted, Figure 4, that the most conspicuous marking on the disk after the polar cap was a broad dark band lying in a nearly north and south direction, but inclined about 10° to the west of south. It reached from the polar cap to the southern maria. Its breadth was about 1200 miles, and its length 1800. Next in visibility came the southern maria themselves, and then a very faint narrow band bounding the cloudy polar zone on the south, and due to the melting snow. Certain of the Associated Observers who were near enough, those located in the United States and Europe, have been informed of this development, and the dates given on which it should be visible to each of them. Should it persist until the next presentation of the planet, it is to be hoped that some of them will secure observations of it.

At this season of its year the whole atmosphere of Mars is filled with haze, which more than the small size of the disk renders observation difficult. In 1913 the haze disappeared at ⊙ 358° or just before the equinox. It is expected therefore that after the middle of October clearer views of the surface may be obtained.

Our next observations were made on September 8, corresponding to the M. D. February 17, central longitudes 292° and 309°. The most conspicuous feature was naturally the Syrtis Major, but the southern maria and the dark boundary of the melting snow were also visible. The last appeared bluish white, and it was thought to be really snow seen between the martian clouds. In 1913 the first snow between clouds was seen M. D. January 23. As compared with that date, and M. D. February 28 of the same opposition, the dark band connecting the Syrtis and the snow cap was much broader and more marked at the present observation. It reached indeed a breadth of over 600 miles, the region following it being much brighter than that preceding it.

Perhaps the most interesting feature of this observation was the complete change which had taken place in the color of the desert regions of the planet since our first observation, July 18, M. D. January 22. This was shown both by the tungsten and carbon lamps. By the former we found the color of the planet was matched in the first instance by a mixture of yellow ochre and raw sienna. It now was matched by golden yellow. By the carbon lamp the former color was yellow ochre; we now found that even white paper was slightly too red. Both lights therefore showed that the planet had lost much of its red color in the seven weeks which had elapsed. Identically the same lamps were used on both dates, and the same storage battery, which had slightly run down in the mean time. This could not have been sufficient to have affected the result however, as the voltage was practically unchanged, and a considerable difference would have been necessary to produce so marked a change in color.

Our next observation was made September 14, corresponding to M. D. February 23. Central longitude 252°. The color observations were repeated and confirmed, except that with carbon, white paper was now markedly too red, and should even have been tinted a light green. With the standard blue tint, giving the planet's true color, it was found to match a mixture of chrome orange and carmine, giving a much more orange, and less red color than we had found on July 18. That the soil or vegetation growing in the so-called desert regions of the planet really changed its color does not by any means follow. The effect is more likely due, either to innumerable minute and invisible clouds, or else general martian haze, produced by the melting of the snow cap at this season of the year. But whatever the cause, the effect was undoubted and striking.

The northern polar cap was very faint and thought to be due to cloud, not snow. The south pole was the same color as the rest of the disk. The maria were distinctly grey, not green. In 1913 they did not begin to turn green until M. D. February 44. It was noted that Mars was 0.2 of a magnitude brighter than Pollux, which was near it, and 0.6 fainter than Saturn.

One of the most striking phenomena of the opposition of 1914 was the conspicuous development of the canal Thoth. On September 30, 1913, corresponding to M. D. January 53, it was clearly seen, and by M. D. March 12 was quite as conspicuous as the northern portion of the Syrtis Major. This year however at M. D. February 23, although it should have been nearly central on the disk, the Syrtis alone was visible. The region following the latter was distinctly brighter than that preceding it, confirming the observation of the previous week. This was doubtless due to clouds condensed from the water vapor rising from the marshy Syrtis region, and in process of transit through the atmosphere to the southern maria. Whether Thoth will appear later as opposition approaches will be a matter of interest. Since the Syrtis itself is so broad this year, it is possible that Thoth may not develop at all, or at all events be less conspicuous than in 1913. It is suggested that other observers should record its first appearance, should it later become visible.

Our next observation was made September 22, corresponding to the M. D. February 31, central longitude 195°. At first the seeing was exceptionally bad, owing to an approaching hurricane,—only 4 in the zenith. The air was very dry, and no detail, not even the snow cap, was recognizable. Later the seeing improved materially, and the snow cap came out, together with glimpses of the dark line bounding it. The southern maria were not certainly seen however. In 1913 on M. D. February 28, the snow cap reached its maximum size, extending down to latitude +42° (Report No. 3). At the present observation it reached latitude +41°. It appeared to be really snow, not cloud, judged by its brilliant whiteness. In 1913 the snow was not entirely clear of cloud until M. D. February 55.

It was interesting to note that the clearing away of the clouds from the snow patch was confirmed by the marked change in color of the planet. With the carbon illumination the color of the paper matching the deserts was no longer a light green as in the last observation, but a distinct golden yellow. Reducing this to terms of the standard blue illumination, the color of the deserts had changed back from orange to red. That is to say the clouds partly obscuring them, which it is to be remembered are yellow on Venus, Jupiter and Mars, had now largely cleared away. During the observations this evening it was necessary

to place the filament of the 2 c.p. lamp at a distance of only 2.5 inches from the paper in order to secure equality of illumination. Possibly the prism or lens in some of the earlier observations was partially dewed. This could not however have affected the color.

TABLE I

DATA OF THE OBSERVATIONS.

No.	1915	⊙	M.D.	Long.	Lat.	Sun	Diam.	Seeing
		°		°	°	°	″	
1	July 18	310.7	Jan. 22	90	− 7	−18	4.8	7
2	Aug. 27	332.9	Feb. 5	63	+ 4	−11	5.3	10
3	Sept. 8	339.5	" 17	292	+ 7	− 8	5.6	6
4	" "	"	" "	309	"	"	"	6
5	" 14	342.7	" 23	252	+ 8	− 7	5.6	10
6	" 22	346.9	" 31	165	+10	− 5	5.8	5

ACUTENESS OF VISION.

Now that Mars will shortly be under observation by many observers, it is thought that it might be of interest to them to be able to test their own acuteness of vision as compared with that of others. On a sheet of tracing cloth seven equi-distant india ink spots were prepared. The mean diameter of the central one, measured under a microscope, was 0.90 mm. The others arranged in a circle about it, diminished in size down to the smallest that could be conveniently drawn with a crow quill. They were located at intervals of half an inch apart, were placed near a window, and viewed at various distances from three to twenty feet, both with the naked eye and with an opera glass. The central spot was visible at the greatest available distance. The results with the others are given in Table II, the first two columns giving the number of the spot and its mean diameter in millimeters, the third and fourth its diameter in arc at the greatest distance at which it could be held clearly in vision, and the resulting deviation from the mean value, and the fifth and sixth its diameter and deviation at the greatest distance at which it could be glimpsed. Both eyes were used. The last four columns give the same results using an opera glass. For some unexplained cause spots 5 and 6 were always more difficult than the others, but there seemed to be no sufficient reason to exclude them from the means. The ratio of the distances "held" and "glimpsed" for both naked eye and opera glass was 0.896. The ratio for the naked eye to the opera glass was 2.71. This seemed to be identical with the magnification of the latter as accurately as it could be determined. The small range of ten per cent between held and glimpsed was unexpected.

The paper was then tacked on the side of a box and placed at a distance of 1011 feet (308 metres) from the objective of the 11-inch telescope. The distance was measured with the micrometer by means of two crosses placed 60 mm apart on the paper. In deducing the distance, the change in scale due to the change in focus of the telescope for short distances is most easily corrected by leaving the constant of the micrometer unchanged, but considering the distance of the object to be measured, not from the objective itself, but from a point situated at the principal focal distance in front of it. That is, we add the focal length of the telescope to the computed result (Harvard Annals, **32**, 122). The angular diameters of the seven spots seen from the objective are 0″.60, 0.″50, 0″.37, 0″.27, 0″.20, 0″.15, and 0″.10.

TABLE II.

VISIBILITY OF BLACK SPOTS.

Spot	Mm.	Held		Glimpsed		Held		Glimpsed	
		Arc	Dev.	Arc	Dev.	Arc	Dev.	Arc	Dev.
		″	″	″	″	″	″	″	″
2	0.75	30.8	−2.8	27.4	− 2.7	—	—	—	—
3	.55	28.6	−5.0	25.7	− 4.4	—	—	—	—
4	.40	25.8	−7.8	24.6	− 5.5	—	—	—	—
5	.30	43.5	+9.9	33.8	+ 3.7	14.8	+2.4	13.2	+2.1
6	.22	40.6	+7.0	40.6	+10.5	13.3	+0.9	11.9	+0.8
7	.15	32.1	−1.5	28.3	− 1.8	9.2	−3.2	8.3	−2.8
Mean		33.6	±5.7	30.1	± 4.8	12.4	±2.2	11.1	±1.9

In the middle of the day the larger spot is occasionally visible for a few seconds at a time as a light hazy blue, about twice its normal size, but as the afternoon wears on, especially if it is cloudy, some of the other spots come out. About three o'clock spot 3 frequently appears, and an hour later spot 5. This is the smallest one we have been able to hold clearly by daylight. The best magnification to use was found to be 330, but dividing the mean size held by the naked eye, 33″.6 by 0″.20, we find that the highest practical magnification of the telescope with daylight seeing is 168.

To test the scale of lakes attached to the tube of the telescope, we measured with it the size of the spots 1, 3, 4, and 5. Their true sizes were 0″.60, 0″.37, 0″.27, 0″.20, their measured sizes were 0″.52, 0″.32, 0″.26 and 0″.20. The ratios in the four cases being 1.15, 1.16, 1.04, and 1.00. This would seem to indicate that measures of the diameters of the lakes of Mars made by this means should be fairly accurate. Observations were also made at night, using a dark lantern to represent the disk of the planet. The results are incomplete; however, improved apparatus has been devised and it is hoped to publish our results later.

There is another test for the eyesight which, in an approximate manner, is more readily applied than that of the dots. Suspend a small weight, such as a tack, by a human hair in an open window or doorway, so that it shall have the open sky for a background, with no glass interposed. Hairs vary somewhat in size, and so do different parts of the same hair. If the hair is used within a few inches of the root, and a microscope is not available with which to measure it, approximate results may be obtained by assuming the diameter at 0.085 mm. The outer extremity of a long hair may not exceed 0.045mm. The writer found that by using both eyes the hair could be held in steady vision at 50 feet, could be glimpsed at 60 feet, occasionally glimpsed at 70, but was invisible at 80. With his best or observing eye alone, it could be held at 50 feet, with the other at 29 feet.

TABLE III.

VISIBILITY OF FINE LINES.

Feet	Arc	Remarks	Arc	Remarks
	″		″	
50	1.15	Held	1.13	Perfectly visible
60	0.97	Continually glimpsed	0.96	Visible but not easy
70	0.82	Occasionally glimpsed	0.83	Visible but difficult
80	0.72	Not visible	0.73	Well glimpsed

In Table III in the first three columns are given the distances at which the hair was observed, its angular diameter, and the remarks upon its visibility. It is not possible to determine the distances closer than to five per cent, since the eye varies constantly in acuteness. The fourth and fifth columns are extracted from a Table published in Bulletin No. 2 of the Lowell Observatory, and describe Dr. Lowell's observations on an iron wire 0.0726 inches in diameter, which was viewed from distances varying from 500 to 2100 feet. Considering the difference in the methods employed, the results may be said to confirm one another satisfactorily, although it would appear that Dr. Lowell felt a little more certain of what he saw than did the writer. Dr. Lowell states that his assistant Mr. Lampland almost exactly concurred in his results. These figures may therefore be considered as fairly representative of the eye-sight of three practical Martian observers. A few persons without any astronomical training were tested, and were found able to hold the hair in steady vision at distances ranging from 14 to 42 feet.

The difference in angular size of the equally visible line and dot is very striking. The ratio is 31. Two pinholes a millimeter apart in a

piece of black paper placed against the light could be separated, that is black could be seen between them, when their distance was eight feet, giving an angular separation of 86″. One felt uncertain of the separation of two parallel lines when their angular distance was reduced to 69″ (Harvard Annals **32**, 151).

Two hairs were next stretched across the illuminated disk at night, and viewed with the telescope. Magnifications of 330 and 430 were about equally satisfactory but on neither of the nights tried was the seeing on the disk as good as it often is in the heavens. At intervals the hairs could be clearly seen. The larger one measured 0″.053 the smaller 0″.029. It was recorded one afternoon that the larger hair was midway in difficulty between the third and fourth spots, diameter 0″.32. Ratio of diameters 6.0. Applying these results to Mars, when at such a distance that its diameter measures 15″, the smallest lake visible, 0″.20, would be 60 miles (96 km) in diameter, and the narrowest canal nine miles (14 km). Ratio 6.7. Too much stress must not be laid on these values however, since the seeing on Mars is often better than it was on the disk, and on the other hand neither the lakes nor canals of Mars are absolutely black, like the dots and hairs. These will serve as preliminary figures, but we should really wait until the planet comes nearer us, and the finer lakes and canals are well seen. They can then be compared with the scales of dots and lines attached to the side of the telescope, and we may by this means hope to secure fairly reliable results. In Bulletin No. 2, Dr. Lowell estimates the breadth of the narrowest canals visible at three-quarters of a mile. This expressed in arc would be 0″.0025.

There is still a third test of acuteness of vision which requires no apparatus at all. If the full moon be viewed with the naked eye, or through spectacles if necessary, there are besides the conspicuous features, certain others which stand out with more or less clearness The finest details are seen when the moon is not very far above the horizon, as it is then less dazzling, and the position of the observer is not too constrained. Twelve objects have been selected upon its surface of increasing degrees of difficulty, those that are dark being followed by a D. They are as follows:—

TABLE IV.

LUNAR TEST OF ACUTENESS OF VISION.

1 Copernicus	5 Gassendi region	9 Medii D
2 Nectaris D	6 Plinius region	10 Sacrobosco region D
3 Humorum D	7 Vaporum D	11 Huygens region D
4 Kepler	8 Lubiniezky region	12 Riphaen Mts.

The relative visibility of the objects varies with the proximity of the terminator. Therefore it is better in general to observe when the moon is nearly full. It was necessary to select objects at some little distance from the limb, to avoid the effect of libration. One should have an opera glass at hand, as well as a map of the moon, in order to determine exactly what one should expect to see. Most of these markings need little description in order to identify them. Medii appears as a narrow line running east and west, and situated to the west of a very dark spot. The Sacrobosco region is a faintly shaded area whose diameter is equal to the length of Crisium. The Huygens region is a dark spot north-east of the Apennines. Knowing it was there, I was able to glimpse it readily, but should not have discovered it otherwise. The Riphaean Mountains are difficult. It is questionable if they are visible to the naked eye. The first ten objects should be discovered, however, and clearly seen by anyone having really good eyesight.

Contents, Index, Lists, and Errata.

Owing in part to the pressure of other work, and in part to the lack of an entirely satisfactory available map, it has not been possible as yet to complete the discussion of all the data secured at the last opposition. In the meantime observations of the coming opposition have already begun, and since ten Reports have now been issued, it appears desirable to supply a table of contents, index, a list of authorities and of illustrations, and a table of errata up to date. The volume and two page numbers appear in each case, the first two referring to Popular Astronomy, and the last to the reprints. The number of the Report is also given in each table, the two series of numbers being separated by a dash when necessary. The paper on the Double Canal in the Lunar Crater Aristillus is also included in these tables, since it may be considered as a supplement to Report No. 5. It is indicated in the tables by an A.

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Errata and Defects.

Since on account of the distance of the Harvard Station in Jamaica from the publication office in Northfield it is impossible for the writer to see a proof of his Reports, more errors and also more misprints occur than would otherwise be the case. The more important ones are corrected below.

Vol.	22,	1,	line	3	Report	1,	1	line	3	*For* 33′ *read* 30′.5
"	"	9	"	7	"	"	9	"	7	" Pithonius *read* Tithonius
"	"	224	"	24	"	4	2	"	3	" thin " their
"	"	299	"	3	"	5	5	"	3	" the " their
"	"	"	"	6	"	"	"	"	6	*Omit* not
"	"	"	"	15	"	"	"	"	15	*For* no *read* not
"	"	300	"	15	"	"	6	"	15	" regions *read* region
		—		—	"	"	10	"	22	" arge " large
"	"	409	"	5	"	6	3	"	5	" canal " canals
"	"	413	"	8	"	"	7	"	8	" the " their
"	"	420	"	36	"	"	14	"	36	" 500 " 150
"	"	574	"	14	Aristillus		5	"	3	" eastern " western
"	"	575	"	20	"		6	"	9	" 120° " 130°
"	"	576	"	7	"		"	"	39	" apparition " opposition
"	"	"	"	15	"		7	"	4	" 30° " 60°
		—		—	"		"	"	29	" midnigh " midnight
"	"	577	"	40	"		8	"	29	" never " seldom
"	"	578	"	10	"		"	"	41	*After* favored *insert* it
"	"	618	"	—	Report	7	2		—	*Under* Figure 8 *for* 1890 *read* 1892
"	"	624	"	20	"	"	8	"	20	*After* one *insert* third of a
"	"	625	"	13	"	"	9	"	13	*For* It is *read* Is it
		—		—	"	8	1	"	36	*After* determine *insert* if
"	"	217	"	24	"	"	2	"	24	*For* P.E.R. Phillips *read* T.E.R. Phillips
"	"	219	"	7	"	"	4	"	7	" region *read* regions
"	"	"	"	9	"	"	"	"	9	*After* impressed *insert* by
"	"	224	"	43	"	"	9	"	43	*For* Gihon *read* Gehon
"	"	229	"	33	"	"	14	"	33	" those " these
"	"	288	"	38	"	9	4	"	38	" near " nearly
"	"	293		—	"	"	9		—	In the Figure, the fourth year counting from the left should be 1916, not 1915.
Vol.	23,	293	line	18	Report	9,	9	line	18	*Omit* seen
"	"	295	"	12	"	"	11	"	12	*For* made *read* given
"	"	462	"	28	"	10,	2	"	28	" 35.19 *read* 35.21
"	"	"	"	34	"	"	"	"	34	" 53".15 " 53".17
"	"	463	"	40	"	"	3	"	40	" 18.3 " 18.2
"	"	464	"	45	"	"	4	"	45	" 159 " 150
"	"	465	"	42	"	"	5	"	42	" 37 " 38
"	"	"	"	55	"	"	"	"	55	" 100.5 " 100.9
"	"	466	"	6	"	"	6	"	6	" 159.0 " 169.0
"	"	472	"	11	"	"	12	"	11	" canal " canals

A few defects have occurred in the illustrations. Thus in Report No. 6, Figure 3, several of the canals B, E, and G, do not show sufficient contrast to give results corresponding to the text. It may perhaps be mentioned here that in the paper on the Meteorology of the Moon, published in the number for March 1915, although not included in this series of papers, the Figures in the frontispiece do not show nearly enough contrast, and that Figure 9 is printed as a negative, i. e. the snow is black and the rocks white. This last error was corrected on page 323, and in the Reprints that were distributed later a correct Figure was inserted, but in this last case the Figure showed altogether too much contrast, making it difficult to compare it with the other eight Figures. The publishers cannot be held responsible for errors in securing the proper contrast in the Figures, and it is only on rare occasions that there is anything to complain of, but it is one of the disadvantages under which the writer labors in not being able to see a proof of his articles.

CHRONOGRAPHIC REGISTRATION OF RADIO TIME SIGNALS.

FRANK D. URIE.

The Elgin National Watch Company, Elgin, Ill., is now obtaining chronographic records of the Arlington Radio time signals at a distance of 700 miles.

The recording apparatus, which was devised by the writer, is entirely automatic in operation,—the incoming radio signals controlling the movement of the chronograph pen.

The following is a brief description of the apparatus. The T-shaped antenna consists of four wires, each 280 ft. long and 150 ft. high. To this antenna is connected a Telefunken Receiving Set, which is of the inductively coupled transformer type using galena detector.

The rectified detector current is led to a series of amplifiers which intensify the Arlington signals sufficiently to operate a very sensitive relay, the back points of which control a 5 ohm pony relay, which in turn controls the chronograph circuit. Experience showed that the

operation of the sensitive relay is very delicate and only a weak current could be put through the back points without their sticking together.

The lag of the apparatus was found to be three hundredths (0.03) of a second.

In comparing the Arlington Signals with the Mean Time Clock Riefler 224 of the Elgin Observatory, the writer has devised the following method for eliminating the consideration of the above lag.

Riefler 224 is not directly connected with the Chronograph, but its beats are recorded indirectly as follows: In our Radio Laboratory there is a relay (operated by Riefler 224) which controls all the sounders in the factory. This factory circuit is strong enough to produce a small spark at the back points of the relay each second as the circuit is broken. This spark is of sufficient intensity to generate electrical waves which are audible in the Radio Receiver as a sharp click. These signals pass through the Amplifying Device, operate the Sensitive Relay and are recorded on the Chronograph in exactly the same manner as the Arlington signals.

Hence any lag that may be present in the Recording Device will affect equally the radio time signals and the signals from the local clock, and is therefore eliminated from the discussion.

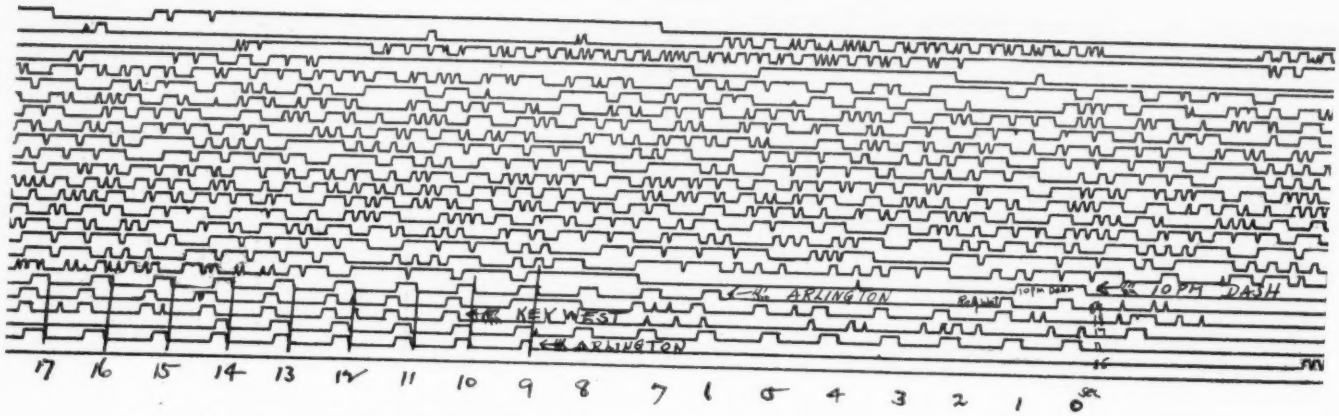
We find that the recording device works reliably under ordinary conditions. Static will be recorded. Hence when the static is stronger than Arlington it is difficult to decipher the sheet. Fortunately at Elgin we are remarkably free from static except during the hot summer months. As far as we know, we are the first institution to obtain chronographic records of the Arlington Time Signals.

This recording device with some modifications was used at the U. S. Naval Observatory for determining the wire lag between the Naval Observatory and Arlington, Radio, Va.

CHRONOGRAPHIC DETERMINATION OF THE LAG BETWEEN THE ARLINGTON AND THE KEY WEST RADIO TIME SIGNALS.

FRANK D. URIE.

The apparatus used at Elgin, Ill., for chronographically recording the Arlington (700 miles) and the Key West (1250 miles) Radio Time Signals has been described in the preceding paper.



A Portion of the Chronographic Record of Wireless Signals Obtained at the Elgin National Watch Co. on January 29, 1915.

The transmitting clock at the U. S. Naval Observatory sends the time signals by wire to Arlington and also to Key West. At each of these radio stations the wire signals are automatically converted into radio signals. Owing to the 900 miles of telegraph wire between Washington and Key West involving several make-circuit relays, the Key West Radio Time Signals lag perceptibly on the Arlington radio time signals.

While developing the radio recording device, the writer found that it was possible to record at Elgin, both the Arlington and the Key West Radio Time Signals on the same chronograph sheet. The determination of the time lag between Arlington and Key West was undertaken in January 1915 at the request of Capt. Hoogewerff, Supt. of the U. S. Naval Observatory. During February the investigation was interrupted by the destruction of our antenna in a sleet and wind storm. The antenna was replaced as soon as possible and the investigation was continued through March.

The plan was to record the first minute of Arlington, then tune to Key West and record the second, third and fourth minutes; then tune again to Arlington and record the fifth minute.

The accompanying reproduction of part of the chronograph sheet of January 29, 1915 shows how this was done. After the record is obtained, vertical lines are drawn between the same seconds of the first and fifth minutes of Arlington. The lag of Key West can then be directly measured for every individual second. This method has the advantage that it eliminates entirely any errors in the teeth of the contact wheel of the transmitting clock, as the lag is always measured from the records of the same individual second.

The results of the lag determination are

1915	Number of Comparisons	Lag of Key West
Jan. 23	29	0.277 sec.
26	16	0.250
29	77	0.267
Mar. 8	22	0.240
10	48	0.120

Apparently there was some unusual lag on March 10 in the Arlington Signals. This date has therefore been rejected in taking the average result of the determination, which gives the lag between Arlington and Key West as $+0.258$ sec.

Elgin, Ill.

EIGHTEENTH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

[*Continued from page 497.*]

ABSTRACTS OF PAPERS.

THE VARIABILITY OF THE SUN.

By C. G. Abbot.

Measurements of the solar constant of radiation made by the Astrophysical Observatory of the Smithsonian Institution at Mount Wilson, California, from 1905 to 1914 indicate increased radiation at times of increased solar activity shown by sunspots, faculae, et cetera. In 1913 at sunspot minimum the mean of all solar constant values was 1.88 calories, which is the lowest yearly mean yet found. In 1914 with the returning solar activity the mean solar constant value for the year was 1.95. This high value seems likely to be reached or exceeded in 1915.

Besides this long period solar fluctuation attending increased solar activity in general, a short irregular solar variation has been observed in all seasons at Mount Wilson, and confirmed by simultaneous observing at Bassour, Algeria, in 1911 and 1912. This irregular fluctuation ranges from 1.8 to 2.0 calories in extremes, but seldom exceeds three or five per cent in any one excursion. Its average period is about ten days. In the year 1913 such variations were more notable than usual, but in 1914 they were unusually small in range.

Both the long period and the short period types of solar variation are found to occur also in the contrast of brightness between the center and edge of the Sun. Spectro-bolometric examination of the distribution of brightness along the diameter of the solar disk was made in Washington in the years 1905 to 1908, and has now been taken up regularly at the Smithsonian station at Mount Wilson, beginning in September 1913. It appears that the contrast was decidedly less in 1913 than in 1905-1908. But in 1914, with the return of solar activity, the contrast returned almost to its value for 1905-1908. Thus increased contrast attends increased solar activity, and increased solar radiation. But the short period fluctuations of solar radiation are attended by fluctuations of contrast in the opposite sense. For them increased contrast attends decreased radiation.

This points to a two-fold cause in the Sun. Increased solar activity, by bringing new and hotter material to the surface, produces increased radiation and increased contrast. Again increased opacity of the outer solar envelopes would produce increased contrast but decreased radiation.

PRELIMINARY NOTE ON THE DETERMINATION OF THE POSITION OF THE MOON BY PHOTOGRAPHY.

By C. E. Adams.

The experiments described here were carried out at the Lick Observatory with the intention of ascertaining if satisfactory photographs of the Moon and surrounding stars could be secured from which the position of the Moon could be obtained with high accuracy.

The lens is a doublet by Brashear, 4¼ inches aperture, 15 feet focal length, corrected for λ 4500, rear surface is flat, front surface convex of 74.73 inches radius. The circular focal plane shutter is two inches in diameter. The plates are Seed No. 27, 8x10 inches and cover about 2° 30′ in declination and 3° 10′ in right ascension. The scale is 1-inch = 1152″. The image of the Moon is 1.6 inches in diameter, so that the shutter is large enough to screen the Moon for an exposure of several minutes. All plates have been taken without guiding.

Plate No. 27 was taken on 1915 July 24 when the Moon was nearly full, the exposures were of six minutes on stars and 0.28 seconds on the Moon. On this plate stars as faint as 9.7 magnitude are easily seen.

The fogging of the plates is much less than was anticipated from published accounts of experiments on this problem. This may be due to the long focal length used.

It will be noticed that in this method no interference is made in the optical train: In this respect it differs from the Harvard Observatory method where the stellar images are affected by the screen used in front of the objective.

The experiments which were made at all ages of the Moon show that satisfactory plates can be secured even at full moon, and that the fogging is not sufficient to prevent accurate measurement of the plates.

My hearty thanks are tendered to Director W. W. Campbell for facilities afforded me in carrying out these experiments.

THE RADIAL VELOCITIES OF THE MORE DISTANT STARS.

By Walter S. Adams.

Among the stars whose radial velocities have been observed at Mount Wilson are many which have either very small or very large proper motions. Those of small proper motion are stars of great aver-

age distance while those of large proper motion include the stars nearest to the Sun. An analysis of the radial velocities by Kapteyn and Adams has shown that the two star streams are represented among the more distant stars as well as among the nearer.

A second result is that the radial velocity increases rapidly with the amount of proper motion. Thus, for the F, G, and K type stars we find a velocity, corrected for the solar motion, of about 10.5 km for stars having an average proper motion of 0″.012 annually, and of about 25 km for stars with a proper motion of 0″.5 annually. For the B and A stars the range in proper motion is too small to make a similar conclusion certain, but the very few A-type stars of very large proper motion give high average velocities.

The relationship between radial velocity and spectral type for the very distant stars is shown in the adjoining table. The velocities are corrected for a solar motion of 20 km directed toward the apex $\alpha = 17^h\ 59^m$, $\delta = +\ 30°.8$. The effect of stream motion has been eliminated approximately by the method devised by Eddington.

Spectral Type	No. Stars	μ	V'	V' corrected for stream motion
		″		
B	61	0.016	8.2 km	8.2 km
A	55	0.019	10.0	7.7
F	20	0.011	10.1	8.8
G	63	0.013	10.6	9.2
K	56	0.014	11.5	10.0
M	27	0.015	12.6	10.9

It is clear from these results that the variation of radial velocity with spectral type is a very gradual one for these distant stars, and it is possible that it might disappear completely were our knowledge of the stream motions such as to enable us to apply rigorous corrections.

The rapid variation of radial velocity with proper motion might be explained by either one of two hypotheses: the nearer stars, as was once suggested by Eddington, may move more rapidly than the distant stars; or, there may be a relationship between velocity and absolute magnitude, and perhaps between velocity and mass. Some support is added to Halm's hypothesis of the equipartition of energy among the stars by the fact that the stars of very low absolute brightness and of large parallax have exceptionally high velocities.

A STATISTICAL STUDY OF THE VISUAL DOUBLE STARS IN THE NORTHERN SKY.

By R. G. Aitken.

The double star survey, initiated in April 1899, was completed in February 1915, from the north pole to $-14°$ declination for the winter half of the sky, and to $-22°$ declination for the summer half.

It has yielded 4300 new double stars, 1328 discovered by Professor Hussey, the others by the writer. Twenty-eight of these have angular separation slightly exceeding 5″.00; 3199 (74.4 per cent) fall within the limit 2″.00, and 1280 (29.8 per cent) within the limit 0″.50. The program included all BD stars down to the 9.0 magnitude, (Mr. Hussey added the 9.1 stars in the zones he examined) and 90 per cent of the 4300 discoveries are as bright as 9.0.

The main purpose of the survey, held definitely in mind by the writer from the beginning, was not discovery, but the accumulation of data, for statistical studies. The present paper gives the conclusions so far obtained from a study of the number and distribution of the double stars in the northern half of the sky.

(1). North of the celestial equator the BD contains 100979 stars as bright as 9.0 magnitude. Of these I find 5400 to be visual double stars within the limits set by my "working definition of a double star." Allowing for the fact that part of the survey was made with the 12-inch refractor, it is thus shown that at least one star in eighteen is a close double star visible in the 36-inch telescope.

(2). The percentage of double stars is greater in the region of the Milky Way than elsewhere in the sky.

(3). Tabulating the 5400 double stars with the arguments *magnitude* and *angular separation*, it is found that in each magnitude class the number of pairs increases as the angular separation diminishes. Assuming that stars of a given magnitude class are at the same average distance from us, this implies that double star systems with relatively small orbits are in the majority.

(4). The spectral class of 1056 of these stars is known. It is found that 711 of them are of classes B8 to F8, 278 of classes G to K0. This confirms the conclusion based on 164 of the more rapidly moving binary stars on my observing program, that visual double stars show a strong preference for spectral classes A and F, and are rarely found among stars of very early or very late type spectra. The distribution of the stars in general among the various spectral classes must, however, be kept in mind in this connection.

Further study of the data is in progress.

THE ORBIT OF AETHRA.

By Dinsmore Alter.

The asteroid Aethra was discovered by Professor Watson on June 10 1873. Orbits were computed by him and later by Luther. The planet has not been seen since twenty-two days after its discovery. Its orbit has been recomputed and the range of solution determined. This

range is very large and it is impossible to find the asteroid by means of a search ephemeris. An observation made at the Lowell Observatory in 1913 can be accurately represented by an orbit based only on the 1873 observations, in which the mean daily motion alone is assumed. This orbit also represents the 1873 observations very closely. It seems quite possible that the two are identical, and if so, Aethra should easily be found this year. A search ephemeris has been computed and in a short time will be published with a full discussion of the problem.

PHOTOGRAPHIC COMPARISON OF A BRIGHT NEBULA WITH A DARK ONE, AND THE POSSIBLE LUMINOSITY OF SPACE.

By E. E. Barnard.

The discovery of many dark objects on the photographs taken with the Bruce telescope of the Yerkes Observatory, often in regions of the sky where there is no ordinary nebulosity and where the stars are too few to form a luminous background for their relief, has led me to believe that there may be a feeble luminosity of space itself sufficiently strong to affect the sensitive photographic plate with very long exposures. This would readily account for these non-luminous bodies being shown in black relief on the plates. This idea is forced upon one in special cases. Often these dark objects are seen in relief against what is palpably a stellar or nebulous background and the explanation of their visibility is evident, but there are other cases in which the stellar or nebulous background does not seem to be the real cause of visibility. The present remarks, therefore, apply to these isolated cases in different parts of the sky.

A lantern slide was exhibited to show one of these dark objects (1855.0, $\alpha = 20^h\ 48^m$, $\delta = +\ 59°.6$) which does not depend on a stratum of stars or an ordinary nebulous background for its visibility. On the slide was also the nebula N. G. C. 6995 in Cygnus which, in form, closely resembles the dark object. It was pointed out that if the nebula should lose its light it would appear in relief as a dark object, very much like the one shown on the slide, if there were a feeble luminosity behind it.

GENERAL RESULTS OF THE MAGNETIC SURVEY OF THE PACIFIC OCEAN BY THE CARNEGIE INSTITUTION OF WASHINGTON.

By L. A. Bauer and W. J. Peters.

The general magnetic survey of the Pacific Ocean, undertaken by the Department of Terrestrial Magnetism of the Carnegie Institution, was begun just ten years ago, at San Francisco. The first vessel used was a chartered one, the "Galilee," with which cruises in all parts of the

Pacific Ocean, to the extent of 60000 miles, were carried out between 1905 and 1908. The balance of the survey has been prosecuted with the aid of the specially constructed vessel, the non-magnetic yacht "Carnegie". This vessel is now cruising in the Pacific Ocean, having made a passage from Balboa, Panama, to Honolulu, during April and May. Leaving Honolulu on July 4, she sailed for Dutch Harbor, Alaska. Thence she will proceed to Port Lyttleton, New Zealand, where she is expected to arrive towards the end of next October.

About the end of November, the "Carnegie" will undertake a circumnavigation cruise embracing the South Pacific, South Atlantic, and the Indian Oceans, between parallels 55° to 60° south. Thus the first general magnetic survey of the Pacific Ocean will be practically completed by the end of the present year.

A summary was given in the paper of the general results obtained during the period 1905 to 1910, both as regards the errors found in the magnetic charts heretofore available to mariners and with respect to the changes in the magnetic elements during the period in question. The theoretical bearings of the results were also briefly discussed.

A summary was also given of the general results of the atmospheric-electric observations made aboard both vessels, the "Galilee" and the "Carnegie."

NOTE ON η ORIONIS.

By A. F. Beal. (*Introduced by Frank Schlesinger.*)

An orbit for this star based on 28 plates secured at Yerkes Observatory was published by Adams in 1902. At the Allegheny Observatory there were secured 27 plates in 1909 and 17 in 1915. All of the Allegheny plates were measured by the writer and the orbit derived agrees with that of Adams in all details except the velocity of the center of mass; Adams gives +35.5 km, the present determination +17.4 km. The probable error per plate is 7.5 km. A large difference between the 1909 and 1915 observations is quite evident. The residuals of both Yerkes and Allegheny plates were added to the velocity of the center of mass to form values mutually comparable. These were combined into normal places each extending over a period not in excess of 50 days. No attention has been given to the individual plate weights. These normals platted with the corresponding Julian Days show a difference of about 12 km between the 1902 and 1909 observations and one of 25 km between the 1902 and 1915 observations. Assuming a long period oscillation due to a third body, the observations can be satisfied approximately by a simple curve whose period is about nine to ten years. Errors of measurement cannot account for the discrepancy as

independent measures made on eight plates give results almost identical with the results of the original measures. The star will be observed throughout the coming winter.

RADIAL VELOCITIES OF THE PLANETARY AND IRREGULAR NEBULÆ.

By W. W. Campbell and J. H. Moore.

The discovery in 1910 that stellar radial velocities increase in general with advancing spectral class has led to the extension of the observing program to include the gaseous planetary and extended nebulæ whose spectra are composed of bright lines, a particular point of interest in the results to be obtained being possible relationships between nebular and stellar velocities which might lead to conclusions respecting the hypothesis of the evolution of stars from nebulae. 348 measures of the velocity of 92 nebulae have been secured at the Lick and D. O. Mills Observatories, working respectively in the northern and southern skies. Single prism spectrographs with cameras of 16 and 18 inches focal-length have been used for the brighter objects, particularly the planetary nebulæ, but for the fainter and extended nebulæ, two-and, three-prism instruments with the eight and five inch cameras have been employed. The advantage of the latter combinations is obvious from the fact that the 3-prism spectrograph, for example, is found to be five or six times as rapid as the one-prism, long-camera instruments while the linear dispersion is the same. By means of these combinations the two green lines of nebulium and the hydrogen line Hβ and occasionally the line at λ 4686 have been photographed with exposures ranging from one to eighteen hours. The measures of velocity obtained from the plates show probable errors ranging from two to four kilometres, depending upon the intensities and number of lines measured.

The results deduced from the observations depend upon 80 out of the total 92 values of velocity, 12 which relate to nebulae in the Magellanic clouds having been excluded because attended by extraordinary circumstances. Seven pertain to the extended or irregular nebulae and 73 to the regular forms such as planetary and annular. All velocities having been freed from the effect of the solar motion, the average velocities of the various groups are found to be:

Of 7 extended nebulae	10	kilometers per second
Of 39 disks and rings	28	"
Of 34 stellar nebulæ	50	"
Of 73 regular forms	38	"

From this it is obvious that velocity increases with respect to the order: extended, disk, stellar forms. It can scarcely be questioned that the

planetary nebulæ may become helium stars, but the hypothesis that helium stars, whose radial velocities thus far observed average 6 kilometers, have in all cases evolved from planetary nebulae appears untenable in view of the six-or seven-fold greater average velocity of planetary nebulæ.

A further significant result is the accordance of the value of the solar motion derived from these nebular velocities with that of 20.2 kilometers derived from Class B stars: namely 20.1 kilometers from the 73 nebulæ of regular form, and 20.7 kilometers from the seven extended nebulæ. It is thus clear that the extended and planetary nebula, are associated, at least in respect to their peculiar motions, with our stellar system. The peculiar motions are furthermore found to be distributed with more or less equal frequency of numbers, a circumstance in marked contrast to that of the helium stars. The evidence of association of the nebulæ with our stellar system is strengthened by strong indications of preferential motions in the direction of Kapteyn's vertices of the two star streams. This is shown in two ways, first by a tabulation with respect to distance from the vertices and second with respect to distance from the central plane of the Milky Way.

Finally, in view of the extraordinary velocities, ranging from 237 to 287 kilometers, of recession found for eleven nebulae in the Greater Magellanic Cloud and the absence of nebulæ in the region of the sky around the Cloud, it is very plausible to conclude that the Cloud is an isolated cosmic unit, a system which has no apparent connection with our own stellar system.

THE NEW DRAPER CATALOGUE.

By Annie J. Cannon.

The classification of spectra for the New Draper Catalogue has now been completed except for a portion of the region in Right Ascension 18^h to 24^h, Declination $-20°$ to $-60°$. On July 27, 1915, the total number of spectra classified was 221601, of which about 180000 have been identified and entered in the Card Catalogue. It is expected that the classification will be completed in October 1915, and that the printing of the Catalogue will be started soon after that time.

NEBULAR PROPER MOTIONS.

By Heber D. Curtis.

Negatives have been secured with the Crossley reflector during the past two years of practically all the objects included in Professor Keeler's program of nebular photography, which was inaugurated in

1899. These two series of plates have been made the basis of measurements, entirely differential in character, to test for internal or translatory motions in the nebulae. The program comprises 136 objects, with an average time interval of 13.85 years, and divided as follows:—

Large extended nebulosities	10
Planetary and annular nebulæ	16
Very small, faint nebulae, most of which are probably spirals	46
Large spiral nebulae	64
	136

Owing mainly to the deficiencies of the old Crossley mounting, many of the old plates are rather poor, a circumstance which greatly diminishes the general accuracy of the results. The attempt has been made however, to make the best of all the material as it stands, and only one or two plates have been rejected.

No evidence has been found for any motion of rotation in the spirals, nor for any relative internal motion of the configurations of the large extended nebulosities. No proper motions of large magnitude have been found for any of the objects of the program; perhaps the largest fairly well determined motions are those found for the two planetaries N.G.C. 6905 and 7009 of 0″.056 and 0″.054 respectively.

The planetaries are perhaps the best determined, with an average proper motion on a great circle of 0″.028 per year. Taking this average proper motion and the average radial velocity of 39 km per second found from Lick Observatory observations on 73 objects of this class,* the average distance of the planetary and annular nebulae is of the order of one-thousand light-years. For the 64 large spirals the average proper motion per year is 0″.025 in $\alpha \cos \delta$ and 0″.022 in δ. Taking Slipher's value of 400 km per second as the average radial velocity of the spirals, this would make the average distance of this class of nebulae of the order of ten-thousand light-years. These values are both probably too small, but no other data are available and for that reason these admittedly conjectural results may be of interest.

NOTES ON VV ORIONIS.

By Zaccheus Daniel.

A least squares solution from measures of seventy spectrograms of VV Orionis gives the following elements:

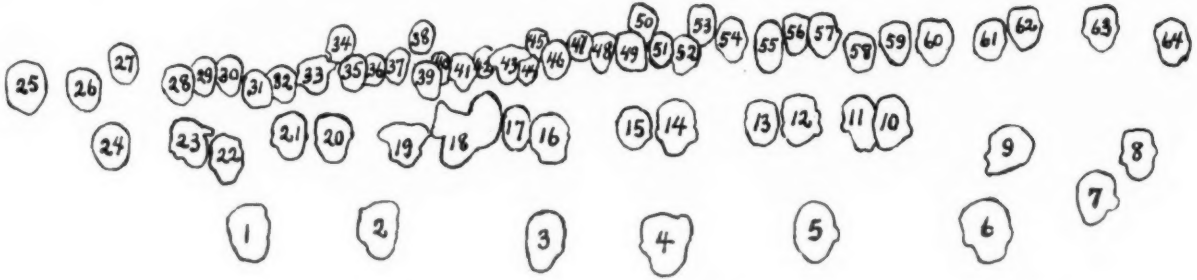
$P = 1.4854$ days	$K = 132.37$ km
$T = 1913$ March 9.021 G.M.T.	$\gamma = +20.77$ km
$e = 0.0$	$a \sin i = 2704000$ km

* See the second paper preceding.

PLATE XXV

JOINT MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY AND THE ASTRONOMICAL SOCIETY OF THE PACIFIC,
BERKELEY, CALIFORNIA, AUGUST 3, 1915

Key to Plate XXV



1. Lee
2. Townley
3. Crawford
4. H. D. Curtis
5. Mitchell
6. Motherwell
7. Stebbins
8. Douglass
9. Apple
10. Leuschner
11. Doolittle
12. Hale
13. Eichelberger
14. Campbell
15. Miss Furness
16. Schlesinger
17. Plaskett
18. Mrs. Campbell
19. Miss O'Halloran
20. Fath
21. Seares
22. Tucker
23. Mrs. Seares
24. Aitken
25. Richardson
26. Ziel
28. Babcock
29. Hamilton
30. Shapley
31. Selga
32. Gray
33. Miss Lamson
34. Turner
35. Molera
36. Miss Harwood
37. Mrs. Lee
38. Cushing
39. Cebrian
41. Miss Hobe
43. Mrs. Adams
44. Miss Swartz
45. Wallace Campbell
46. Larkin
47. Meyer
48. Adams
49. Klotz
50. Wright
51. Joy
52. Swezey
53. Alter
54. Nicholson
55. Costa
56. Moore
57. Einarsson
58. Ichihaski
59. Paddock
60. Brackett
61. Rigge
62. Brasch
63. Truman
64. Mrs. Truman

The probable error of an average plate is 11.9 km. This is 2.0 km larger than the largest previously found here for any other star and it arouses the suspicion of a third body in the system. Upon platting the residuals it is found that there is a tendency to change from negative to positive for the first three months of each season. The maxima being reached on February 16, 1913 and February 11, 1914. This indicates a period of 360 days, or some sub-multiple. It is probable that the true period is one-third of that, or 120 days. Using that period the observations were grouped into ten normal places. From a plat of these normals the following roughly approximate elements were deduced.

$P = 120$ days	$K = 13.0$ km
$T = 1913$ Feb. 20	
$e = 0.30$	$a \sin i = 20460000$ km

Using these elements the probable errors of an average plate is reduced to 10.0 km.

THE CORRELATION OF SUNSPOTS, WEATHER, AND TREE GROWTH.

By A. E. Douglass.

About twenty-five thousand measures of the rings of annual growth of trees in wet and dry climates have been made. The tree growth of North Germany, Scandinavia (excepting the inner fiords of Norway) and parts of the British Isles measured in the *Pinus sylvestris* show a curve of growth during the last ninety years strikingly resembling the sunspot curve. If averaged in eleven year periods the two curves become almost exactly alike. Eleven hemlocks from Vermont and seventeen Douglas firs from Oregon show a similar agreement with the sunspot curve, but the maximum growth of trees precedes the sunspot's maximum by three years.

In the dry climate of Arizona the growth of the pine trees (*Pinus ponderosa*) follows the rainfall with an accuracy of seventy to eighty per cent. (See Pub. A. A. S. Vol. II, 127).

PHOTOGRAPHY OF THE ZODIACAL LIGHT AND GEGENSCHEIN AND OTHER LARGE FAINT OBJECTS.

By A. E. Douglass.

Absolute freedom from city lights is a prerequisite. The full process has three parts: First, the use of a lens of large aperture and short focus, making a small picture. Second, the use of a panorama mechanism with a curved film and a sort of focal plane diaphragm passing a

curved opening across the front of the film. Third, multiple exposures, simultaneous, or in immediate succession, on the faint object up to any number desired; each of these developed to the best advantage, not too dense, and then the entire number placed one above the other in careful registration and prints made from this compound negative. If necessary a similar compound positive is made, from which a final negative with any desired contrasts is obtained.

By these methods repeated photographs of the zodiacal light have been made in the past spring and a number of photographs which are thought to show the gegenschein conspicuously. (The latest form of curved focal plane diaphragm was not constructed in time to be applied in the photographs exhibited.)

THE LIGHT CURVE OF EROS IN 1914.

By Margaret Harwood.

An investigation of the variability in light of the asteroid Eros at each of the successive oppositions since 1893 has been undertaken as part of the work of the writer as Fellow of the Nantucket Maria Mitchell Association. The results for the opposition of 1914 are as follows:

The magnitudes of 121 images of Eros have been measured on photographs taken at the Harvard Observatory and at the Maria Mitchell Observatory in Nantucket on twenty-two nights between August 26 and December 17, 1914. The period, $0.^{d}1098$, obtained by Bailey from the visual and photographic observations of 1903, does not satisfy the photographic observations of 1914. The period of variation obtained from these observations is $0^{d}.3064$. The range of variation is 0.4 magnitudes.

PHOTOGRAPHIC PHOTOMETRY WITH THE 30-INCH THAW REFRACTOR.

By Frank C. Jordan.

Part of the time of the Thaw refractor is used in photographic photometry by the extra-focal method for the purpose of determining the light curves of the fainter short period variables. The individual star images are not of uniform density, being darker in the center and shading toward the edges; they also increase in size as well as density with increase of exposure. However, as only a small part of the image is covered by the silver spot of the microphotometer, and this always the most dense portion, the lack of uniformity does not seem to be detrimental to the accuracy of the measurements. A well measurable image of an eleventh magnitude star can be obtained in about three minutes. The reduction curve of the micro-photometer wedge was

obtained by photographs of the Pleiades and Praesepe clusters, as well as from sensitometer exposures. Light curves of RS *Bootis* and SU *Draconis* have been obtained. The absolute magnitudes are not determined, since the fundamental comparison stars have been used with their BD magnitudes. However the shape and photographic range of the curves are well determined. In the case of RS *Bootis*, the magnitude range is found to be from 9.40 to 10.80, as compared with the visual range of 9.2 to 10.2. For SU *Draconis* the range is from 8.72 to 9.90, as compared with a visual range from 8.9 to 9.6. The ratios of photographic to visual range are respectively 1.4 and 1.7.

AN INVESTIGATION OF THE CLUSTER M 37 (N.G.C. 2099) FOR PROPER MOTION FROM PLATES TAKEN WITH THE 40-INCH REFRACTOR OF THE YERKES OBSERVATORY.

By Alfred H. Joy. (*Introduced by O. J. Lee.*)

The investigation involved the measurement of two plates taken in 1903 and 1904 by Schlesinger and one taken in 1915 by Lee and Sullivan and the comparison of the mean of the first two plates with the last one. 292 stars were measured.

With reference to the mean of all the stars, the central stars of the plate show positive and the outer zones negative residuals, which indicates that the central stars, composing the cluster, are moving with reference to the stars of the sky in the neighborhood. All magnitudes show the same result.

In a second solution the outer zone of the plates was taken as the standard of star distribution in the different magnitudes for that part of the sky. The stars of this zone together with a like distribution of stars over the central regions were considered as reference stars and the second solution was made with reference to them alone. The remaining stars were considered to belong to the cluster proper. The resulting mean centennial proper motion for the 155 stars of the cluster was found to be $0''.66$ in position angle $46^\circ.2$.

PROGRESS WITH THE PHOTO-ELECTRIC PHOTOMETER.

By Jacob Kunz and Joel Stebbins.

During the past year, various improvements have been made in the methods of preparing photo-electric cells in the laboratory, and the photometer has been completely reconstructed. As a result the nstrument has been increased five- or six-fold in effective sensibility.

Whereas a year ago the new instrument was just about equal to the selenium photometer, and could be used, with a 12-inch telescope, for stars down to the third magnitude, it is now possible to secure observations of fifth magnitude objects.

In the summer of 1915, the instrument was taken to Mt. Hamilton and, through the courtesy of Director Campbell, was attached to the 12-inch refractor of the Lick Observatory. During six weeks various stars were observed, and in particular a provisional light-curve was found for the well known variable β *Lyrae*. The new curve does not differ much from the previous curves of visual observers, and the results as a whole are satisfactory. But there is evidence either that one or more of the comparison stars is variable in light, or that the light-curve of β *Lyrae* itself changes. This question is being investigated further.

The accuracy attainable with the photo-electric photometer depends upon the brightness and position of the stars to be observed, but from residuals on separate nights it is found that a probable error of ± 0.005 magnitude may easily be obtained for stars of about magnitude 3.5.

(*To be continued.*)

PLANET NOTES FOR DECEMBER, 1915.

The sun at the beginning of the month will be 21° 41′ south of the equator. It will move south until December 22, reaching its greatest declination south on this date. At this time winter is said to begin. The sun will then move northward to 23° 10′ south declination by the end of the month. The sun will move eastward from Scorpio into Sagittarius during the month.

The phases of the moon for this month are as follows:

New Moon	Dec.	6	at 12 M.	C.S.T.
First Quarter		13	" 6 A.M.	"
Full Moon		21	" 7 A.M.	"
Last Quarter		29	" 7 A.M.	"

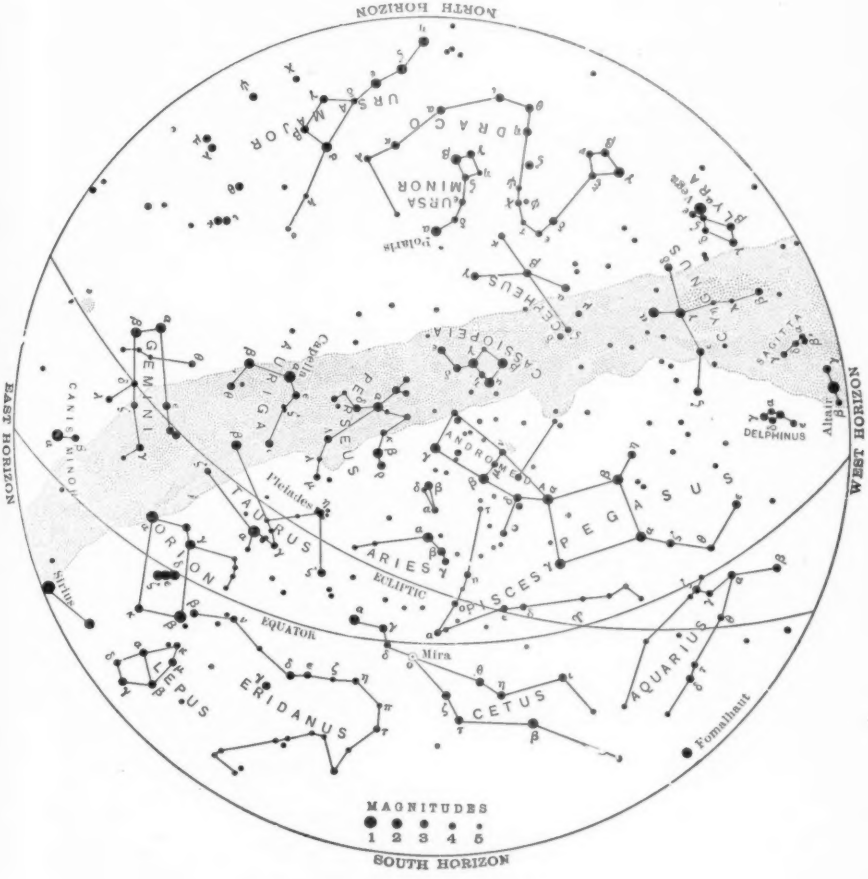
Mercury will be on the opposite side of the sun from the earth on December 15. It will be too near the sun to be visible at any time during December.

Venus will be visible in the west after sunset. It will set about an hour and a half after the sun at the middle of the month. It will be moving eastward more rapidly than the sun and will therefore be a little higher in the sky each evening. It will still be quite low in the sky for careful study.

Mars will be visible well up in the sky in the early morning during this month. It will rise before midnight and be on the meridian about four o'clock in the morning at the middle of the month. It will be in the constellation Leo, quite near to Regulus, the conspicuous star of this constellation. Mars will be approaching the earth, and during this month will come within one hundred million miles of the earth.

Jupiter will continue to be very favorably situated for study during this month. It will be on the meridian at sunset, only a few degrees south of the equator. It is in quadrature with the sun, 90° east, on December 12. It will be between Aquarius and Cetus, in a region in which there are no brighter stars.

Saturn will be favorably situated above the horizon about midnight during this month. At the end of the month it will be on the meridian at midnight. It will be in the constellation Gemini.



THE CONSTELLATIONS AT 9:00 P. M. DECEMBER 1.

Uranus will be found in the constellation Capricornus, and will be visible just after sunset. It will cross the meridian in the afternoon.

Neptune will be between the planets Saturn and Mars during this month. It will be found in the constellation Cancer. It will be on the meridian in the early morning.

Occultations Visible at Washington.

Date 1915	Star's Name	Magnitude	IMMERSION. Washington M.T.	Angle from N.	EMERSION. Washington M.T.	Angle from N.	Duration
			h m	°	h m	°	h m
Dec. 8	ψ Sagittarii	4.9	4 27	107	5 18	209	0 52
11	150 B Aquarii	6.0	9 58	105	10 38	196	0 40
13	22 Piscium	5.8	9 58	99	10 50	200	0 52
14	136 B Piscium	6.5	12 23	28	13 11	285	0 48
16	47 B Arietis	6.5	6 43	42	8 05	252	1 22
18	17 Tauri	3.8	4 46	99	5 42	217	0 56
18	16 Tauri	5.4	4 48	58	5 52	258	1 04
18	q Tauri	4.3	5 17	23	6 05	292	0 48
18	20 Tauri	4.1	5 20	61	6 28	254	1 08
18	22 Tauri	6.5	5 42	28	6 36	286	0 54
18	21 Tauri	5.8	5 44	16	6 27	299	0 43
20	112 B Aurigae	5.7	8 37	34	9 32	311	0 55
21	ϵ Geminorum	3.2	17 11	103	18 13	294	1 02
22	BD+23°1744	6.4	15 40	132	16 54	279	1 14
24	81 Cancri	6.4	16 47	124	18 04	305	1 17
25	18 Leonis	5.8	8 13	84	9 05	313	0 51
25	19 Leonis	6.4	8 47	118	9 45	281	0 58
26	R Leonis(var.)	5-10	9 02	149	9 48	251	0 46
26	35 Sextantis	6.1	15 43	119	17 05	321	1 22
27	359 B Leonis	6.3	11 34	76	12 20	344	0 46

Phenomena of Jupiter's Satellites.

[Visible at Washington.]

CENTRAL STANDARD TIME.

	h m				h m		
Dec. 1	5 49	I	Tr. In.	Dec. 12	8 36	II	Tr. In.
	7 09	I	Sh. In.	14	8 16	II	Ec. Re.
	7 39	IV	Ec. Dis.	15	6 24	III	Oc. Re.
	8 06	I	Tr. Eg.		9 00	III	Ec. Dis.
	9 13	IV	Ec. Re.		9 30	I	Tr. In.
	9 26	I	Sh. Eg.	16	7 00	I	Oc. Dis.
2	6 44	I	Ec. Re.	17	5 30	I	Sh. In.
	10 49	II	Oc. Dis.		6 24	I	Tr. Eg.
4	9 11	III	Tr. In.		7 46	I	Sh. Eg.
5	5 59	II	Tr. In.	18	5 04	I	Ec. Re.
	8 42	II	Sh. In.	21	5 24	II	Oc. Dis.
	8 51	II	Tr. Eg.	22	7 23	III	Oc. Dis.
7	5 38	II	Ec. Re.	23	6 02	II	Sh. Eg.
	10 35	I	Oc. Dis.		8 57	I	Oc. Dis.
8	4 55	III	Ec. Dis.	24	6 06	I	Tr. In.
	7 35	III	Ec. Re.		7 26	I	Sh. In.
	7 44	I	Tr. In.		8 23	I	Tr. Eg.
	9 05	I	Sh. In.		9 42	I	Sh. Eg.
	10 01	I	Tr. Eg.	25	7 00	I	Ec. Re.
9	4 44	IV	Tr. In.	26	5 39	III	Sh. Eg.
	5 04	I	Oc. Dis.	28	8 06	II	Oc. Dis.
	8 00	IV	Tr. Eg.	30	5 51	II	Sh. In.
	8 40	I	Ec. Re.		6 06	II	Tr. Eg.
10	4 30	I	Tr. Eg.		8 38	II	Sh. Eg.
	5 50	I	Sh. Eg.	31	8 04	I	Tr. In.

Note:—In., denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow

V VARIABLE STARS.

Approximate Magnitudes of Variable Stars of Long Period on Oct. 1, 1915.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900.	Decl. 1900.	Magn.	Name.	R.A. 1900	Decl. 1900	Magn.
	h m	° ′			h m	° ′	
X Androm.	0 10.8	+46 27	13.5*d*	U Aurigae	5 35.6	+31 59	11.5
T Androm.	17.2	+26 26	9.0 *i*	SU Tauri	43.2	+19 2	9.8
T Cassiop.	17.8	+55 14	12.0*d*	V Camelop.	49.4	+74 30	<13.0
R Androm.	18.8	+38 1	11.4*d*	U Orionis	49.9	+20 10	9.8*d*
S Ceti	19.0	− 9 53	9.0 *i*	Z Aurigae	53.6	+53 18	12.0
Y Cephei	31.3	+79 48	13.5	X Aurigae	6 4.4	+50 15	12.5*d*
U Cassiop	40.8	+47 43	9.5 *i*	SS Aurigae	5.8	+47 46	<13.5
RW Androm.	41.9	+32 8	12.0*d*	V Aurigae	16.5	+47 45	9.5
V Androm.	44.6	+35 6	12.0 *i*	V Monoc.	17.7	− 2 9	<12.0
RR Androm.	45.9	+33 50	9.6 *i*	U Lyncis	31.8	+59 57	11.5*d*
RV Cassiop	47.1	+46 53	8.2 *i*	S Lyncis	35.9	+58 0	13.6*d*
W Cassiop.	49.0	+58 1	10.5*d*	X Monoc.	52.4	+ 8 56	8.0 *i*
U Androm.	1 9.8	+40 11	13.8	R Lyncis	53.0	+55 28	13.5*d*
UZ Androm.	10.4	+41 12	13.7	R Geminorum	7 1.3	+22 52	7.2
S Cassiop.	12.3	+72 5	12.5*d*	R Can. Min.	3.2	+10 11	7.5 *i*
S Piscium	12.4	+ 8 24	13.0 *i*	S Can. Min.	27.3	+ 8 32	10.0
U Piscium	17.7	+12 21	<13.5	U Can. Min.	35.9	+ 8 37	10.0 *i*
RZ Persei	23.6	+50 20	11.5*d*	U Geminorum	49.2	+22 16	<13.0
R Piscium	25.5	+ 2 22	10.5 *i*	R Cancri	8 11.0	+12 2	10.0*d*
RU Androm.	32.8	+38 10	10.0 *i*	R Urs. Maj.	10 37.6	+69 18	12.0 *i*
Y Androm.	33.7	+38 50	9.5 *i*	T Urs. Maj.	12 31.8	+60 2	7.8*d*
X Cassiop.	49.8	+58 46	12.0*d*	RS Urs. Maj.	34.4	+59 2	<13.0
U Persei	53.0	+54 20	9.0 *i*	S Urs. Maj.	39.6	+61 38	11.8*d*
S Arietis	59.3	+12 3	<13.5	T Urs. Min.	13 32.6	+73 56	9.0 *i*
R Arietis	2 10.4	+24 35	8.4*d*	R Can. Ven.	44.6	+40 2	11.0 *i*
W Androm.	11.2	+43 50	13.2	U Urs. Min.	14 15.1	+67 15	9.6 *i*
Z Cephei	12.8	+81 13	<13.5	S Bootis	19.5	+54 16	8.6*d*
o Ceti	14.3	− 3 26	8.4 *i*	RS Virginis	22.3	+ 5 8	10.5*d*
S Persei	15.7	+58 8	10.0*d*	R Camelop.	25.1	+84 17	8.5*d*
R Ceti	20.9	− 0 38	<13.0	V Bootis	25.7	+39 18	7.6 *i*
RR Persei	21.7	+50 49	9.8*d*	R Bootis	32.8	+27 10	8.6 *i*
U Ceti	28.9	−13 35	8.0 *i*	U Bootis	49.7	+18 6	10.0 *i*
RR Cephei	29.4	+80 42	14.0	S Serpentis	15 17.0	+14 40	10.0*d*
R Trianguli	31.0	+33 50	9.8*d*	S Cor. Bor.	17.3	+31 44	12.8
W Persei	43.2	+56 34	9.8*d*	RS Librae	18.5	−22 33	7.5 *i*
U Arietis	3 5.5	+14 25	<13.0	RU Librae	27.7	−14 59	10.5*d*
X Ceti	14.3	− 1 26	10.2 *i*	S Urs. Min.	33.4	+78 58	10.5*d*
Y Persei	20.9	+43 50	8.4 *i*	R Cor.Bor.	44.4	+28 28	6.1 *i*
R Persei	23.7	+35 20	9.0 *i*	X Cor. Bor.	45.2	+36 35	10.0 *i*
Nov. Per. No. 2	24.4	+43 34	13.0	V Cor. Bor.	46.0	+39 52	9.8 *i*
W Tauri	4 22.2	+15 49	12.0*d*	R Serpentis	46.1	+15 26	12.2*d*
R Tauri	22.8	+ 9 56	12.6*d*	Z Cor. Bor.	52.2	+29 32	13.5*d*
S Tauri	23.7	+ 9 44	<13.5	RZ Scorpii	58.6	−23 50	8.8 *i*
T Camelop.	30.4	+65 57	13.0*d*	R Herculis	16 1.7	+18 38	13.5 *i*
X Camelop.	32.6	+74 56	8.5 *i*	U Serpentis	2.5	+10 12	12.2*d*
RX Tauri	32.8	+ 8 9	12.0 *i*	RU Herculis	6.0	+25 20	12.5*d*
V Tauri	46.2	+17 22	<13.5	W Cor. Bor.	11.8	+38 3	11.8 *i*
R Aurigae	5 9.2	+53 28	11.2*d*	V Ophiuchi	21.2	−12 12	9.5
W Aurigae	20.1	+36 49	11.6*d*	U Herculis	21.4	+19 7	11.2*d*
S Orionis	24.1	− 4 46	10.0 *i*	SS Herculis	28.0	+ 7 3	12.5*d*
S Camelop.	30.2	+68 45	8.0	R Urs. Min.	31.3	+72 28	9.3
T Orionis	30.9	− 5 32	9.5	W Herculis	31.7	+37 32	11.8*d*

Approximate Magnitudes of Variable Stars of Long Period on Oct. 1, 1915—Continued.

Name.	R. A. 1900. h m	Decl. 1900. ° ′	Magn.	Name.	R.A. 1900. h m	Decl. 1900. ° ′	Magn.
R Draconis	16 32.4	+66 58	9.2*d*	R Delphini	20 10.1	+ 8 47	12.2*d*
S Herculis	47.4	+15 7	11.5*d*	RT Capricorni	11.3	−21 38	8.2*d*
RV Herculis	56.8	+31 22	13.5*d*	U Cygni	16.5	+47 35	9.2 *i*
R Ophiuchi	17 2.0	−15 58	10.5*d*	RU Capricorni	26.7	−22 2	<13.0
RT Herculis	6.8	+27 11	12.2*d*	Z Delphini	28.1	+17 7	10.2*d*
Z Ophiuchi	14.5	+ 1 37	11.2*d*	ST Cygni	29.9	+54 38	11.8 *i*
RS Herculis	17.5	+23 1	8.2 *i*	Y Delphini	36.9	+11 31	11.6*d*
RU Ophiuchi	28.1	+ 9 30	9.5 *i*	V Cygni	38.1	+47 47	8.4 *i*
RS Ophiuchi	44.8	− 6 40	11.4	S Delphini	38.5	+16 44	11.5*d*
RT Ophiuchi	51.8	+11 11	<13.0	Y Aquarii	39.2	− 5 12	13.5
T Draconis	54.8	+58 14	10.0	T Delphini	40.7	+16 2	10.6*d*
RY Herculis	55.4	+19 29	14.0	W Aquarii	41.2	− 4 27	12.8 *i*
V Draconis	56.3	+54 53	11.0 *i*	U Capricorni	42.6	−15 9	13.7
T Herculis	18 5.3	+31 0	9.6*d*	V Delphini	43.2	+18 58	<13.0
W Draconis	5.4	+65 56	<13.0	T Aquarii	44.7	− 5 31	7.4
X Draconis	6.8	+66 8	10.0	RZ Cygni	48.5	+46 59	<12.0
W Lyrae	11.5	+36 38	10.6*d*	X Delphini	50.3	+17 16	10.2*d*
RY Ophiuchi	11.6	+ 3 40	12.3 *i*	R Vulpeculae	59.9	+23 26	11.5*d*
SV Herculis	22.3	+24 58	12.0 *i*	TW Cygni	21 1.8	+29 0	11.3*d*
T Serpentis	23.9	+ 6 14	12.8*d*	V Capricorni	1.8	−24 19	11.8
SV Draconis	31.2	+49 18	13.0*d*	X Capricorni	2.8	−21 45	<13.0
RZ Herculis	32.7	+25 58	9.2	X Cephei	3.6	+82 40	11.0 *i*
X Ophiuchi	33.6	+ 8 44	6.8 *i*	Z Capricorni	5.0	−16 35	9.8
RY Lyrae	41.2	+34 34	13.5 *i*	RS Aquarii	5.8	− 4 27	<13.5
RW Lyrae	42.1	+43 32	13.3 *i*	T Cephei	8.2	+68 5	7.7 *i*
R Scuti	42.2	− 5 49	6.2*d*	R Equulei	8.4	+12 23	11.0
Z Lyrae	56.0	+34 49	11.5*d*	RR Aquarii	9.8	− 3 19	10.2
R Aquilae	19 1.6	+ 8 5	6.0 *i*	X Pegasi	16.3	+14 2	11.5*d*
V Lyrae	5.2	+29 30	<13.0	T Capricorni	16.5	−15 35	13.8
RW Sagittarii	8.1	−19 2	9.3	Y Capricorni	28.9	−14 25	13.6
RX Sagittarii	8.7	−18 59	9.7	S Cephei	36.5	+78 10	10.8 *i*
S Lyrae	9.1	+25 50	<13.0	RU Cygni	37.3	+53 52	8.6
U Draconis	9.9	+67 7	13.5	SS Cygni	38.8	+43 8	11.8
W Aquilae	10.0	− 7 13	13.6*d*	RR Pegasi	40.0	+24 33	10.6*d*
RY Sagittarii	10.0	−33 42	6.8	V Pegasi	56.0	+ 5 38	<13.0
T Sagittarii	10.5	−17 9	11.3	U Aquarii	57.9	−17 6	11.7
R Sagittarii	10.8	−19 29	7.6 *i*	RT Pegasi	59.8	+34 38	12.2 *i*
TZ Cygni	13.4	+50 0	10.5	T Pegasi	22 4.0	+12 3	13.5
S Sagittarii	13.6	−19 12	<13.5	Y Pegasi	6.8	+13 52	<13.5
Z Sagittarii	13.8	−21 7	9.0 *i*	RS Pegasi	7.4	+14 4	11.0 *i*
U Lyrae	16.6	+37 42	12.0*d*	X Aquarii	13.2	−21 24	13.7
TY Cygni	29.8	+28 6	14.0*d*	RT Aquarii	17.7	−22 34	10.3
RT Aquilae	33.3	+11 30	12.0*d*	RV Pegasi	21.0	+29 58	<13.0
R Cygni	34.1	+49 58	10.7*d*	S Lacertae	24.6	+39 48	8.8
RV Aquilae	35.9	+ 9 42	9.8	R Lacertae	38.8	+41 51	12.0 *i*
RT Cygni	40.8	+48 32	7.8 *i*	S Aquarii	51.8	−20 53	11.2 *i*
TU Cygni	43.3	+48 49	13.0 *i*	RW Pegasi	59.2	+14 46	13.4*d*
X Aquilae	46.5	+ 4 13	13.3*d*	R Pegasi	23 1.6	+10 0	10.4 *i*
χ Cygni	46.7	+32 40	10.5 *i*	V Cassiop.	7.4	+59 8	8.0 *i*
RR Aquilae	52.4	− 2 11	13.8*d*	W Pegasi	14.8	+25 44	11.0*d*
RS Aquilae	53.7	− 8 9	11.5 *i*	S Pegasi	15.5	+ 8 22	11.0*d*
Z Cygni	58.6	+49 46	12.8	Z Androm.	28.8	+48 16	10.5
SY Aquilae	20 2.3	+12 39	12.5	ST Androm.	33.8	+35 13	9.2*d*
S Cygni	3.4	+57 42	13.5 *i*	R Aquarii	38.6	−15 50	8.0*d*
R Capricorni	5.7	−14 34	11.8*d*	Z Cassiop.	39.7	+56 2	<13.5
S Aquilae	7.0	+15 19	11.5*d*	RR Cassiop.	50.7	+53 8	11.2
RU Aquilae	8.0	+12 42	10.0 *i*	R Cassiop.	53.3	+50 50	9.2 *i*
W Capricorni	8.6	−22 17	10.8 *i*	Z Pegasi	55.0	+25 21	9.8 *i*
RS Cygni	9.8	+38 28	8.8	Y Cassiop	58.2	+55 7	12.0 *i*
Z Aquilae	9.8	− 6 27	13.5*d*	SV Androm.	59.2	+39 33	10.5*d*

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:—H. C. Bancroft, Jr., T. C. H. Bouton, A. B. Burbeck, L. Campbell, H. O. Eaton, W. P. Hoge, S. C. Hunter, J. B. Lacchini, O. Mach, C. Y. McAteer, C. S. Mundt, G. F. Nolte, W. T. Olcott, D. B. Pickering, C. F. Richter, F. H. Spinney, H. M. Swartz, H. W. Vrooman, I. E. Woods and A. S. Young.

Minima of Variable Stars of Short Period.

[Calculated by Elva Utzinger at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5h; Central Standard 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1915 December							
	h m	° ′		d h	d	h	d	h	d	h	d	h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8	2	11						
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	2	11;	10	3;	17	19;	25	11
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	6	0;	13	10;	20	20;	28	7
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	1	8;	8	20;	16	7;	31	6
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	6	22;	13	0;	19	3;	31	9
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	1	11:	8	14;	15	18;	30	0
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	6	15;	13	11;	20	8;	27	5
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	4	0;	11	4;	18	8;	25	12
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	3	0;	11	19;	20	13;	29	8
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	7	8;	15	7;	23	6;	31	4
RX Cassiop.	58.8	+67 11	8.6— 9.1	32 07.6	7	15						
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	4	10;	10	4;	15	22;	27	9
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	6	21;	13	17;	20	12;	27	7
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	2	18;	10	16;	18	13;	26	11
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	7	12;	15	20;	21	3		
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	7	21;	15	18;	23	16;	31	13
RW Persei	13.3	+42 04	8.8—11.0	15 04.8	4	10;	17	15;	30	20		
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	1	13;	11	0;	20	11;	29	21
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	9	15;	22	2				
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	6	10;	13	2;	19	18;	26	10
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	1	11;	6	23;	17	20;	28	18
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	2	6;	8	6;	14	7;	26	8
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	9	14;	18	6;	26	22		
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	3	15;	14	1;	24	12		
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	2	7;	10	6;	18	7;	26	8
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	6	15;	12	9;	18	2;	29	13
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	4	15;	10	5;	15	19;	27	0
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	9	2;	17	7;	25	11		
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	5	2;	12	17;	20	8;	27	23
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	6	23;	19	4;	31	9		
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	2	10;	9	14;	23	22;	31	2
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	5	21;	15	0;	24	2		
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	1	9;	10	16;	20	0;	29	7
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	6	7;	16	5;	26	3		
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	7	15;	16	0;	24	10		
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	2	17;	9	3;	15	14;	28	10
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	7	3;	14	9;	21	16;	28	22
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	2	21;	19	3;	27	6		
S Cancri	8 38.2	+19 24	8.2—10	9 11.6			10	9;	19	21;	29	8
RX Hydrae	9 0.8	− 7 52	9.1—10.5	2 6.8	5	3;	14	6;	23	9		
S Antliae	27.9	−28 11	6.7— 7.3	0 07.8	4	4;	10	15;	17	3;	30	2
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	4	1;	10	0;	15	22;	27	19
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	4	17;	13	4;	21	14;	30	0
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	2	21;	12	4;	21	10;	30	17
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	2	15;	9	5;	15	20;	29	1
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	1	19;	10	14;	19	10;	28	5
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	2	3;	9	11;	16	18;	31	10

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1915 December							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	6 19;	13 13;	20 8;	27 3				
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	7 5;	14 17;	22 5;	29 18				
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	7 18;	15 4;	22 15;	30 1				
δ Librae	14 55.6	— 8 07	4.8— 6.2	2 07.9	2 12;	9 12;	16 11;	30 11				
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	3 10;	10 7;	24 3;	31 0				
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.4	2 13;	11 0;	19 10;	27 20				
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	1 11;	9 3;	16 19;	24 11				
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	2 16;	10 0;	17 8;	24 17				
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	6 4;	14 10;	22 16;	30 22				
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	7 21;	16 18;	25 14					
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	9 14;	19 7;	30 9					
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	3 14;	10 9;	17 4;	24 0				
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	5 23;	14 8;	22 17;	31 2				
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	3 8;	9 12;	21 19;	27 23				
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	2 15;	9 20;	17 1;	31 11				
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	5 15;	13 0;	20 9;	27 17				
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	2 23;	11 3;	19 8;	27 12				
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	7 1;	14 14;	22 3;	29 15				
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	6 7;	14 1;	21 19;	29 12				
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	4 7;	12 7;	20 6;	28 6				
WX Sagittae	53.6	−17 24	9.2—10.8	2 03.1	1 12;	10 0;	18 13;	27 1				
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	3 5;	12 13;	21 21;	31 5				
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	1 19;	12 3;	22 11					
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	3 7;	10 12;	17 18;	25 0				
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	7 17;	14 15;	21 12;	28 10				
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2	2 20;	17 23						
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	7 4;	15 10;	23 16					
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	4 0;	12 22;	21 19;	30 17				
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	7 11;	15 18;	24 2					
RR Draconis	40.8	+62 34	9.3—13	2 19.9	8 3;	16 15;	25 3					
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	6 17;	13 8;	19 23;	26 15				
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8		12 0;	24 22					
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	5 3;	14 17;	24 6					
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	4 7;	11 21;	19 11;	27 0				
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	1 14;	8 19;	15 23;	30 9				
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	7 4;	16 2;	25 1					
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	6 22;	13 17;	20 11;	27 5				
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	4 0;	11 9;	18 17;	26 2				
TT Lyrae	24.3	+41 30	9.3—11.6	5 05.8	2 6;	7 12;	18 0;	28 12				
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	2 21;	9 9;	15 22;	28 23				
SY Cygni	19 42.7	+32 28 10	—12	6 00.2	5 7;	11 8;	17 8;	29 8				
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	4 12;	11 3;	17 18;	31 1				
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	9 14;	18 18;	28 21					
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	1 13;	10 0;	18 10;	26 20				
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	5 16;	12 11;	19 6;	26 1				
UW Cygni	19.6	+42 55	10.5—13	3 10.8	7 6;	14 4;	21 1;	27 23				
V Vulpec.	32.3	+26 15	8.2—9.8	37 19.0								
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	4 15;	14 6;	23 21					
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	9 19;	19 0;	28 5					
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	2 7;	9 18;	17 6;	24 18				
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	1 19;	7 15;	19 8;	31 0				
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2		10 20;	20 23;	31 1				
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	5 16;	13 1;	20 10;	27 19				
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	9 3;	18 20;	28 13					
RY Aquarii	14.8	−11 14	8.8—10.4	1 23.2	2 3;	10 0;	17 20;	25 17				
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3		14 7						
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	2 16;	12 20;	22 23					
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	3 1;	8 5;	18 14;	28 23				
X Lacertae	22 45.0	+55 54	8.2— 8.6	5 10.6	4 3;	9 13;	20 10;	31 8				
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.3	8 14;	16 21;	25 4					
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	5 3;	12 15;	20 4;	27 17				
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	6 16;	14 22;	23 4;	31 9				

Maxima of Variable Stars of Short Period.

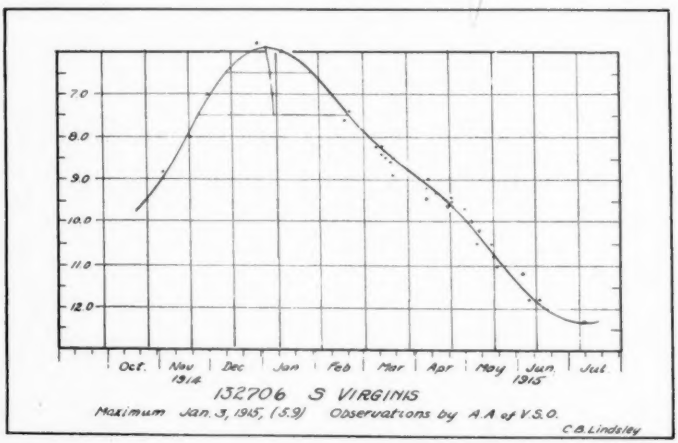
[Calculated by Julia M. Hawkes and Agnes E. Wells at Goodsell Observatory.]

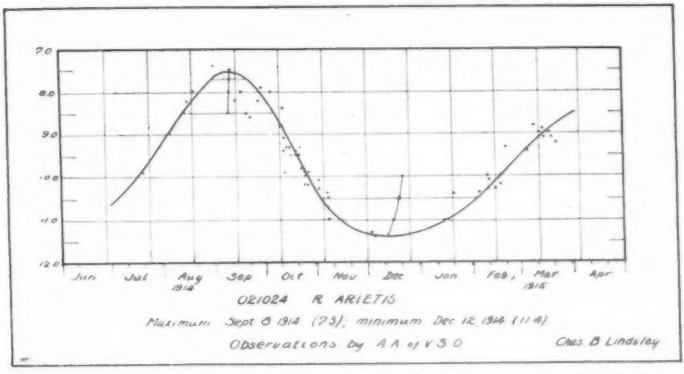
Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5^h; Central standard time 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1915. December							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	
SX Cassiop.	0 05.5	+54 20	8.6— 9.4	36 13.7	5 10							
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	9 23;	18 2;	26 5					
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	5 7;	13 1;	20 18;	28 12				
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	4 12;	19 7						
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	5 15;	13 14;	21 13;	29 11				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	6 9;	14 4;	21 23;	29 18				
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	4 17;	12 0;	19 6;	26 13				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	1	17						
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	8 0;	16 14;	25 4					
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	3 12;	14 15;	25 18					
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	6 11;	18 2;	29 17					
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	8 2;	15 17;	23 9;	31 1				
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	1 23;	12 2;	22 5					
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	6 16;	14 9;	22 3;	29 20				
RZ Gemin.	5 56.6	+22 12	9.1—10.0	5 12.7	1 21;	7 10;	18 11;	29 12				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6		15 6;	22 20;	30 9				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3		11 17						
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	4 20;	12 1;	19 6;	26 10				
W Gemin.	6 29.2	+15 24	6.7— 7.5	7 22.0	2 1;	9 23;	17 21;	25 19				
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	3 1;	13 5;	23 8					
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5		17 4						
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	3 21;	11 19;	19 18;	27 17				
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	6 3;	12 20;	19 12;	26 5				
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	8 8;	17 15;	26 21					
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	2 22;	11 16;	19 10;	28 4				
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 0.0	2							
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	4 20;	11 15;	18 10;	31 23				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	1 1;	7 16;	14 6;	27 11				
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	1 1;	13 17;	20 8;	30 0				
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	6 2;	14 2;	22 1;	30 0				
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	6 5;	12 23;	19 16;	26 10				
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	2 18;	8 14;	14 10;	20 6				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	1 0;	10 9;	19 18;	29 3				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5		10 22;	28 5					
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	7 5;	15 10;	23 14;	31 19				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	6 7;	13 7;	20 8;	27 8				
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	4 8;	12 13;	20 19;	29 0				
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	0 15;	11 14;	22 14;	28 2				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	7 4;	14 17;	22 6;	29 19				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	6 9;	13 19;	21 5;	28 15				
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	5 18;	12 12;	19 7;	26 2				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	2 8;	8 16;	15 0;	27 15				
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	9 23;	19 17;	29 11					
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	3 15;	12 11;	21 8;	30 5				
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	1 15;	7 17;	19 19;	31 23				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	7 18;	14 18;	21 18;	28 19				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9		17 23						
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	1 11;	9 1;	16 16;	31 20				
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	6 14;	12 8;	18 3;	29 16				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	4 17;	11 11;	18 5;	31 17				
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	6 22;	17 6;	27 14					
Y Lyrae	34.2	+43 52	11.3—12.3	0 12.1	1 10;	7 11;	19 13;	31 14				
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	4 21;	11 0;	17 3;	21 10				
RT Scuti	18 44.1	−10 30	9.1— 9.7	0 11.9	1 18;	7 17;	19 15;	31 12				
κ Pavonis	18 46.6	—67 22	3.8— 5.2	9 02.2	6 21;	16 0;	25 2					

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1915. December							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	7 15;	14 15;	21 16;	28 16				
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	1 6;	8 6;	15 6;	29 6				
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	7 16;	15 15;	23 15;	31 14				
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	8 8;	16 1;	23 18;	31 10				
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	1 20;	9 1;	16 5;	30 13				
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	5 7;	13 16;	22 1;	30 10				
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	6 10;	12 18;	19 2;	31 17				
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	9 5;	25 14						
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	3 21;	12 18;	21 15;	30 11				
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	7 3;	13 20;	20 14;	27 7				
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	6 15;	13 8;	20 1;	26 19				
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4		10 6;	24 23					
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	3 0;	10 21;	18 17;	26 14				
SW Aquarii	10.2	— 0 20	9.9—10.8	0 11.0	4 22;	11 20;	18 17;	25 15				
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	4 0;	8 20;	18 14;	28 7				
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	1 21;	10 12;	19 4;	27 19				
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	3 11;	8 20;	19 13;	30 7				
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	4 10;	15 7;	26 4					
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	2 13;	8 23;	15 9;	28 5				
V Lacertae	22 44.5	+55 48	8.2— 8.9	4 23.6	5 7;	10 6;	20 5;	30 4				
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	1 20;	7 7;	18 4;	29 1				
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	1 4;	7 22;	20 12;	26 19				
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	7 14;	19 17;	31 21					
V Cephei	23 51.7	+82 38	6.0—7.0	0 23.6	4 20;	9 19;	19 19;	29 18				

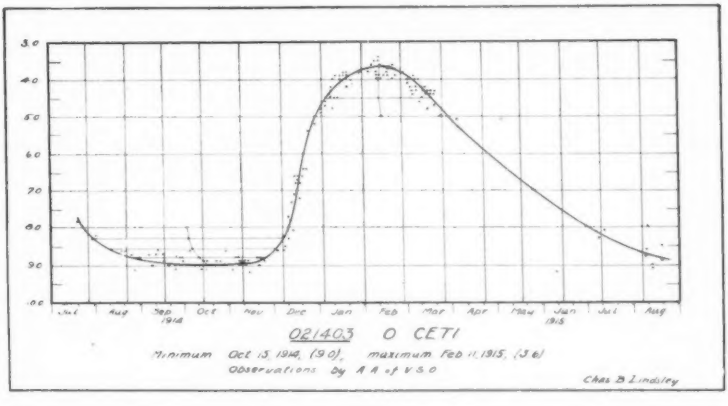




021024 R. ARIETIS

Maximum Sept. 8 1914 (7.3), minimum Dec. 12, 1914 (11.4)

Observations by A.A. of V.S.O. Chas. B. Lindsley

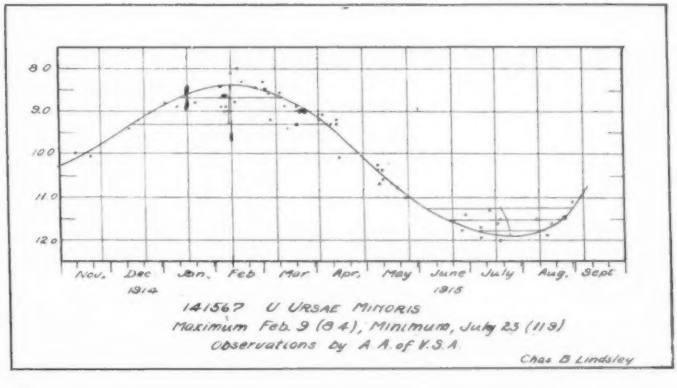


021403 O CETI

Minimum Oct. 13, 1914, (9.0), maximum Feb. 11, 1915, (3.6)

Observations by A.A. of V.S.O.

Chas. B. Lindsley



141567 U URSAE MINORIS

Maximum Feb. 9 (8.4), Minimum, July 23 (11.9)

Observations by A.A. of V.S.A.

Chas. B. Lindsley

COMET AND ASTEROID NOTES.

Ephemeris of Comet 1915 *a* (Mellish).—The following ephemeris is taken from a circular issued by the Royal Observatory of the Collegio Romano.

EPHEMERIS FOR GREENWICH MIDNIGHT.

Date		True α	True δ	log *r*	log Δ	Mag.
		h m s	° ′ ″			
1915 Dec.	2	4 7 7.54	+ 1 16 39.6	0.370564	0.146843	
	4	4 3 16.03	+ 1 58 33.5			
	6	3 59 34.82	+ 2 39 44.8	0.379350	0.163839	
	8	3 56 4.23	+ 3 20 9.7			
	10	3 52 44.54	+ 3 59 45.0	0.387936	0.181892	11.8
	12	3 49 35.91	+ 4 38 28.3			
	14	3 46 38.41	+ 5 16 17.7	0.396332	0.200761	
	16	3 43 52.02	+ 5 53 12.0			
	18	3 41 16.65	+ 6 29 10.8	0.404544	0.220210	
	20	3 38 52.17	+ 7 4 14.0			
	22	3 36 38.40	+ 7 38 21.7	0.412578	0.240033	
	24	3 34 35.12	+ 8 11 34.5			
	26	3 32 42.11	+ 8 43 53.5	0.420440	0.260046	
	28	3 30 59.14	+ 9 15 20.2			
	30	3 29 25.85	+ 9 45 55.7	0.428136	0.280099	
1916 Jan.	1	3 28 1.99	+10 15 41.8			
	3	3 26 47.46	+10 44 40.0	0.435672	0.300062	
	5	3 25 42.05	+11 12 51.9			
	7	3 24 45.55	+11 40 19.6	0.443050	0.319855	12.8

E. MILLOSEVICH.

Rome, Sept. 6, 1915.

Comet 1915 *d* (Mellish).—Mr. F. E. Seagrave sends in the following ephemeris, based on the elements given on page 536 of our last issue. He says, "The comet during November will be very unfavorably situated for observation, being low down in the southwest immediately after sunset, and in very strong twilight. On November 15 it will be nearly 5° south of *Antares*. On November 5 the distance between the comet and Venus will be only 0.1134 of our distance from the sun, about 10,487,000 miles." As the elements used were derived from a very short arc of the comet's path the above statements and the ephemeris may be subject to large errors.

EPHEMERIS OF COMET *d* (MELLISH).

1915		α	δ	log *r*	log Δ
		h m s	° ′ ″		
Nov.	2	15 28 43	−19 50 33	9.82815	0.19777
	6	15 47 34	−23 44 16	9.86985	0.21262
	10	16 05 53	−27 12 40	9.90875	0.22761
	14	16 23 50	−30 17 30	9.94503	0.24273
	18	16 41 33	−32 56 06	9.97867	0.25784
	22	16 58 56	−35 23 21	0.00989	0.27283
	26	17 16 09	−37 28 00	0.03887	0.28758
	30	17 33 10	−39 16 51	0.06583	0.30206
Dec.	4	17 49 57	−40 49 20	0.09095	0.31613
	8	18 06 29	−42 09 20	0.11447	0.32982

Elements and Ephemeris of Comet 1915 *d* (Mellish).—The results given below were obtained by S. Einarsson and Dinsmore Alter of the Students' Observatory of the University of California, Berkeley, Cal., from the following observations made by Aitken:

1915 Gr. M. T.	Comet's Apparent α	δ
	h m s	° ′ ″
Sept. 20.01972	10 37 03.58	+26 13 17.1
21.01756	10 44 54.83	+25 47 31.0
23.02787	11 01 00.09	+24 47 47.8

ELEMENTS.

T	1915 Oct. 13.39590	
ω	118° 50′ 03″.4	1915.0
Ω	77 42 52 .0	1915.0
i	53 32 41 .0	1915.0
q	0.443296	
log q	9.646694	

CONSTANTS FOR THE EQUATOR 1915.0.

$$x = r\,[9.791293]\,\sin\,(278^\circ\ 42'\ 22''.8 + v)$$
$$y = r\,[9.963492]\,\sin\,(221\ \ 39\ \ 46\ \ .2 + v)$$
$$z = r\,[9.943933]\,\sin\,(145\ \ 05\ \ 37\ \ .6 + v)$$

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

Date	True α	True δ	log ρ	Br.
	h m s	° ′ ″		
Oct. 17.5	14 08 32.1	− 2 02 01	0.1380	2.49
21.5	14 32 21.5	− 7 43 57	0.1489	
25.5	14 54 20.8	−13 08 53	0.1607	1.56
Oct. 29.5	15 15 01.5	−18 08 52	0.1737	
Nov. 2.5	15 34 49.8	−22 40 38	0.1875	0.90
6.5	15 54 04.9	−26 43 49	0.2020	
10.5	16 12 59.7	−30 19 21	0.2170	0.53
14.5	16 31 41.0	−33 29 11	0.2322	
18.5	16 50 14.1	−36 15 04	0.2475	0.33
22.5	17 08 40.3	−38 39 08	0.2627	
26.5	17 26 59.8	−40 43 19	0.2778	0.22
Nov. 30.5	17 45 11.1	−42 29 32	0.2926	
Dec. 4.5	18 03 12.0	−43 59 33	0.3070	0.15

Report of the Comet Committee on Halley's Comet.—In the Publication of the American Astronomical Society Vol. II, Part 2, appears the Report of the Comet Committee appointed by the Society in 1908, with special reference to Halley's Comet. The report contains an index catalog of all the photographs of Halley's Comet which have been reported to the Committee, with reproductions of 47 photographs taken by Ferdinand Ellerman at Diamond Head, Hawaiian Islands, and notes on these photographs by Professor Barnard.

The number of photographs listed in the index catalog is 1979 and this is not complete, for we notice that the list from the Lowell Observatory is missing and it is possible that some others may not have been reported. In order to fill up the gaps likely to occur in the series of photographs as a result of the fact that "about one-third of the earth's circumference in longitude is covered by the Pacific Ocean, within which there is known to exist no observatory with proper facilities for celestial photography" the committee sent Mr. Ferdinand Ellerman of the Mount Wilson Solar Observatory to Honolulu in April 1910 with instructions to occupy the most advantageous site that could be found for photographing the comet. The National Academy of Sciences made a grant of funds for the purpose; the Lick Observatory loaned a six-inch equatorial mounting, the John A. Brashear Company of Pittsburg a six-inch camera, and the Bausch & Lomb Company of Rochester, New York, a Tessar lens. The photographs obtained by Mr. Ellerman are excellent and the reproductions are very good.

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, Sept.-Oct., 1915.

It is a pleasure to welcome as new members of our Association this month the following observers:

Mr. John C. Crane, "Cr" Sandwich, Mass.
Mr. George F. Nolte, "Nt" Weston, Mass.
Mr. James L. Steuart, "Se" Montclair, N. J.
Mr. Carlos Lacombe, "La" Rio de Janeiro, Brazil.

Mr. Nolte, who observes with a five-inch refractor, has already made a number of observations and contributes to this report.

We are indebted to Mr. Wendell P. Hoge, "Ho", of the staff of the Mt. Wilson Solar Observatory in California, for a fine set of observations of southern variables observed with the six-inch refractor on Mt. Wilson.

There has lately been installed at the headquarters of the Agassiz Association at Sound Beach, Conn., a six-inch Clark equatorial in a suitable building. This fine equipment was obtained by public subscription, and largely through the efforts of Dr. Edward F. Bigelow, the managing editor of "The Guide to Nature" the publication of the Agassiz Association. It is Dr. Bigelow's desire to promote through the use of this telescope a widespread public interest in Astronomy, and incidentally he expects to coöperate with us in the observations of variables.

Messrs. Lacchini, McAteer, and Richter deserve great credit for their many contributions of early morning observations. During the past month Mr. McAteer observed ninety-eight variables, an enviable record.

Observations of the variable 054974 V Camelopardalis are desired. It is claimed that this variable is in the class with 074922 U Geminorum, and for this reason it should be observed at every opportunity.

Our activity is well attested by the fact that during the past month we have recorded positive observations of 179 variables, which exceeds our best record in this respect thus far.

We expect to have a meeting of the Association in Cambridge, Mass., the third week in November. Professor Pickering has very kindly invited our members to visit the Harvard College Observatory. In addition to the pleasure of meeting together this is an exceptional opportunity to inspect the observatory. It is hoped that many of our members will be able to attend this meeting.

Attention is called to an error in the chart of the variable 161138 W Coronae Borealis. Members who have this chart will please make the following correction: Strike out the figures 108 or 100 where they now appear. Insert the figures 100 close to the bright star south of the 11.2 at the angle of the outlined triangle.

The following members contributed to this report:—Messrs. Bancroft, Bouton, Burbeck, Eaton, Hoge, Hunter, Lacchini, McAteer, Mundt, Nolte, Olcott, Pickering, Richter, Spinney, Vrooman, Miss Swartz and Miss Young.

This report concludes our fourth year of work, and the detailed statement of the number of observations contributed by each member is published herewith. It indicates gratifying progress in which every one concerned may well take pride.

No small part of our success and progress is due to the constant and steady distribution of the blue prints. Many members have assisted in this valuable work and the Secretary's records show that during the past year he has distributed over eight hundred charts.

VARIABLE STAR OBSERVATIONS Sept.-Oct., 1915.

001032
S Sculptoris

Mo.	Day	Est	Obs.
9	7	12.4	Ho

001726
T Androm.

Mo.	Day	Est	Obs.
9	2	11.0	Sp
	3	11.0	Sp
	7	10.6	M
	7	10.8	E
	9	10.9	Sp
	10	10.9	O
	10	10.7	Sp
	12	9.9	V
	28	9.2	O
	29	9.3	V
	29	9.2	Pi
	29	8.9	Ba
10	4	9.1	O

001755
T Cassiop.

Mo.	Day	Est	Obs.
9	3	11.8	B
	5	11.5	M
	10	11.6	Sp
	28	10.5	Pi

001838
R Androm.

Mo.	Day	Est	Obs.
9	2	10.4	Sp
	3	10.5	Sp
	9	10.8	Sp
	10	10.9	O
	15	11.0	Pi
	15	10.6	B
	28	11.6	Pi
	29	11.4	Ba

001909
S Ceti

Mo.	Day	Est	Obs.
9	6	9.5	R
	7	9.5	Ho
	10	9.4	Sp
	10	9.8	Pi
	11	9.5	Sp

002614
T Piscium

Mo.	Day	Est	Obs.
9	29	9.4	M

004047
U Cassiop.

Mo.	Day	Est	Obs.
9	3	11.0	B
	7	11.3	E
	29	9.7	Y
	29	9.8	Pi
	29	9.9	S

004533
RR Androm.

Mo.	Day	Est	Obs.
9	10	11.1	O
	28	9.7	O
	28	9.7	M
10	4	9.5	O

004746
RV Cassiop.

Mo.	Day	Est	Obs.
9	29	8.6	Pi

004958
W Cassiop.

Mo.	Day	Est	Obs.
9	2	9.2	Sp
	3	10.0	B
	10	9.7	Sp
	14	10.1	O
	19	10.5	M
	22	9.6	B

010102
Z Ceti

Mo.	Day	Est	Obs.
9	7	8.8	Ho

011208
S Piscium

Mo.	Day	Est	Obs.
9	29	12.8	B

011272
S Cassiop.

Mo.	Day	Est	Obs.
9	3	11.9	B
	6	12.0	M

012502
R Piscium

Mo.	Day	Est	Obs.
9	8	10.6	M

013338
RU Androm.

Mo.	Day	Est	Obs.
9	28	8.3	M
	29	7.5	Pi

013338
Y Androm.

Mo.	Day	Est	Obs.
9	28	10.0	M
	29	10.2	Pi

014958
X Cassiop.

Mo.	Day	Est	Obs.
9	3	12.0	B
	19	11.1	M
	28	11.4	Pi
	29	12.5	Y

015254
U Persei

Mo.	Day	Est	Obs.
9	3	10.3	B
	10	9.9	Sp
	11	9.8	Sp
	12	10.4	V
	19	10.0	M
	22	9.4	B
	29	9.3	V

021024
R Arietis

Mo.	Day	Est	Obs.
9	6	9.1	R
	10	8.5	Pi
	15	8.5	Pi
	28	8.4	Pi

021403
o Ceti

Mo.	Day	Est	Obs.
9	6	9.1	R
	6	8.6	E
	7	8.3	Ho
	10	8.4	Pi
	12	8.7	L
	16	8.7	L

021258
T Persei

Mo.	Day	Est	Obs.
9	15	8.9	Pi

021658
S Persei

Mo.	Day	Est	Obs.
9	2	9.1	Sp
	3	8.9	B
	5	9.7	R
	6	9.3	R
	10	8.8	Sp
	12	9.0	R
	14	9.4	R
	15	9.4	Pi
	15	9.4	R
	17	9.5	R
	19	9.0	M

022150
RR Persei

Mo.	Day	Est	Obs.
9	29	9.6	Y

022101
R Ceti

Mo.	Day	Est	Obs.
9	15	11.0	Ho

022813
U Ceti

Mo.	Day	Est	Obs.
9	6	9.4	R
	7	8.8	Ho

023133
R Triang.

Mo.	Day	Est	Obs.
9	2	9.2	Sp
	9	9.6	Sp
	12	9.7	M

024356
W Persei

Mo.	Day	Est	Obs.
8	29	10.3	R
9	3	9.8	R
	4	9.7	R
	5	9.9	R
	6	9.9	R
	8	9.5	M
	10	9.3	Pi
	12	9.4	M
	12	10.0	R
	15	9.4	Pi
	16	9.4	L

031401
X Ceti

Mo.	Day	Est	Obs.
9	6	11.6	E

032043
Y Persei

Mo.	Day	Est	Obs.
9	6	9.5	R
	8	9.3	M

032335
R Persei

Mo.	Day	Est	Obs.
9	15	9.1	Pi
	19	9.1	M

033362
U Camelop.

Mo.	Day	Est	Obs.
9	6	8.6	R

035915
V Eridani

Mo.	Day	Est	Obs.
9	6	9.3	R
	7	8.5	Ho

042249
R Tauri

Mo.	Day	Est	Obs.
9	11	12.0	Sp
	14	11.8	M

042215
W Tauri

Mo.	Day	Est	Obs.
9	10	11.9	Sp
	14	12.0	M

043274
X Camelop.

Mo.	Day	Est	Obs.
9	10	11.6	Sp
	11	11.4	Sp
	16	11.0	L

043208
RX Tauri

Mo.	Day	Est	Obs.
9	6	12.8	E
	14	12.2	M

045514
R Leporis

Mo.	Day	Est	Obs.
8	25	7.7	L
9	6	7.9	R
	7	7.0	Ho
	12	6.9	L
	15	8.0	M
	16	6.3	L

050022
T Leporis

Mo.	Day	Est	Obs.
9	7	12.1	Ho
	15	10.4	Ho
	15	11.4	M

052034
S Aurigae

Mo.	Day	Est	Obs.
9	12	11.0	L
	13	10.4	M

052036
W Aurigae

Mo.	Day	Est	Obs.
9	6	9.6	R
	12	10.7	Sp
	14	10.5	M
	22	10.4	M

052405
S Orionis

Mo.	Day	Est	Obs.
9	15	10.0	Ho

053005
T Orionis

Mo.	Day	Est	Obs.
9	12	9.3	L
	14	9.7	M
	15	9.5	Ho
	22	9.5	M

054920
U Orionis

Mo.	Day	Est	Obs.
9	6	8.8	R
	12	8.8	L
	14	8.8	M

055353
Z Aurigae

Mo.	Day	Est	Obs.
9	7	10.6	E
	14	10.7	M

065820
ζ Gemin.

Mo.	Day	Est	Obs.
9	6.0	4.4	R

060224
S Leporis

Mo.	Day	Est	Obs.
9	19	6.5	Ho

065208
X Monoc.

Mo.	Day	Est	Obs.
9	12	8.6	L
	15	8.3	Ho

065820
TW Gemin.

Mo.	Day	Est	Obs.
9	27	8.5	M

070122
R Gemin.

Mo.	Day	Est	Obs.
9	27	7.2	M

070312
R Can. Min.

Mo.	Day	Est	Obs.
9	14	8.6	L
	27	7.7	M

072708
S Can. Min.

Mo.	Day	Est	Obs.
9	14	10.3	L
	15	10.3	M
	22	10.2	M
	27	10.1	M

073508
U Can. Min.

Mo.	Day	Est	Obs.
9	12	10.7	L

073722
S Gemin.

Mo.	Day	Est	Obs.
9	22	8.7	M

074323
T Gemin.

Mo.	Day	Est	Obs.
9	22	9.1	M

VARIABLE STAR OBSERVATIONS Sept.-Oct., 1915—Continued.

075613
U Puppis
Mo. Day Est. Obs.
9 21 11.1 Ho

081112
R Cancri
9 14 9.4 L

081733
T Lyncis
9 27 11.4 M

090151
V Urs. Maj.
9 16 9.5 L

093178
Y Draconis
9 28 12.0 Y

103769
R Urs. Maj.
9 27 12.1 Ba

123160
T Urs. Maj.
8 23 7.8 R
24 7.6 R
25 7.6 R
28 7.8 R
29 7.8 R
9 2 8.2 Bu
3 7.5 R
4 7.8 E
4 7.4 R
5 7.9 M
5 7.2 R
6 7.2 R
12 7.7 M
12 8.1 O
12 7.4 R
14 7.3 R
15 7.8 B
15 7.6 M
15 7.3 R
16 7.2 R
17 7.1 R
19 8.0 O
22 8.0 M
24 7.7 Ba
25 7.6 B
28 7.9 M
29 8.0 Nt

123961
S Urs. Maj.
9 2 10.2 B
4 10.8 E
5 10.9 M
12 11.2 M
15 11.3 M
27 11.6 Ba
27 11.8 B
28 10.7 R
29 10.6 Nt
29 10.8 R

133273
T Urs. Min.
Mo. Day Est. Obs.
9 2 9.6 Bu
24 9.0 Ba

134440
R Can. Venat.
9 12 11.4 M
15 11.8 B
28 11.2 M

141567
U Urs. Min.
9 4 10.9 E
7 10.9 M
24 10.7 Ba
27 9.8 B
29 10.0 S

141954
S Bootis
8 23 8.8 R
24 8.9 R
25 8.8 R
28 8.2 R
29 8.2 R
9 2 8.8 Bu
3 8.2 R
4 8.3 R
5 8.2 R
6 8.9 L
6 8.4 R
7 9.1 M
10 8.6 Pi
10 8.8 O
12 7.7 R
14 7.9 R
14 8.8 O
15 8.2 R
16 8.3 R
17 8.6 R
18 8.4 R
19 8.8 O
24 8.6 Ba
27 8.5 Nt
28 8.7 O
10 6 8.9 S

142205
RS Virginis
8 29 9.0 L

142539
V Bootis
8 23 9.9 R
24 9.6 R
25 9.8 R
27 9.2 L
28 9.5 R
29 9.5 R
9 2 9.0 Ba
2 8.8 Bu
3 9.8 R

V Boötis
Mo. Day Est. Obs.
9 4 9.4 R
5 9.2 R
6 9.0 R
7 8.6 M
8 8.5 Pi
8 9.1 L
10 8.4 Pi
12 8.3 R
14 8.3 R
15 8.1 R
16 7.9 R
17 8.2 R
18 8.1 R
24 7.9 Ba

142584
R Camelop.
9 2 8.8 Bu
10 8.4 O
14 8.4 O
16 8.4 L
19 8.3 O
25 8.4 B
28 8.5 O
10 4 8.7 O

143227
R Bootis
9 2 10.6 Bu
6 10.9 L
15 9.7 M
28 8.7 Ba

144918
U Bootis
9 15 10.4 M

151614
S Serpentis
9 2 9.4 Bu
4 9.3 L
12 9.6 V

151731
S Cor. Bor.
8 31 12.5 B
9 10 10.8 Hu
30 12.6 B

151822
RS Librae
8 31 8.4 L

152714
8 28 11.0 R
29 9.8 L
29 11.0 R

153378
S Urs. Min.
Mo. Day Est. Obs.
8 23 9.4 R
24 9.3 R
25 8.8 R
28 9.1 R
29 9.3 R
9 2 9.2 Bu
3 8.6 R
4 9.0 R
5 9.1 M
5 9.2 R
6 9.5 R
12 9.6 R
14 10.3 R
16 10.9 R
16 9.7 L
17 10.0 R
18 9.9 R
24 9.5 Ba
25 9.4 B
29 10.4 O
29 10.5 Nt

154428
R Cor. Bor.
8 20 8.3 L
23.7 8.6 R
24.7 8.6 R
25 8.3 L
27 8.2 L
28.7 8.2 R
29.7 8.3 R
29 8.3 L
31.5 8.0 B
31 7.9 L
9 1.5 7.8 M
1.6 7.4 E
2.5 7.6 Bu
2.5 7.8 Ba
2.5 8.0 B
3.5 8.0 B
3.6 8.4 R
4 7.6 L
4.5 7.4 E
4.5 8.0 B
4.6 8.2 R
5.5 7.8 M
5.6 7.8 R
6 7.9 L
6.5 7.6 B
6.6 7.7 M
6.6 7.9 R
7.6 7.0 E
7.6 7.6 M
8 7.5 L
8.5 7.0 Pi
8.6 7.5 M
9.5 7.2 E
9.5 7.5 O
9.6 7.3 Mu
10 7.2 Hu

R Cor. Bor.
Mo. Day Est. Obs.
9 10.5 7.6 O
10.5 7.4 Bu
10.5 7.3 Pi
10.6 7.4 M
12 7.2 L
12 7.2 V
12.5 7.4 O
12.5 7.2 M
12.5 7.2 Bu
12.6 6.6 R
13.6 6.8 E
14 7.0 Hu
14.5 7.1 M
14.5 7.0 O
14.6 6.1 R
15 6.9 Hu
15.5 7.0 O
15.5 6.9 B
15.6 7.0 M
15.6 6.0 R
16 6.9 L
16.6 6.1 R
17.6 6.2 R
18.5 6.7 B
18.6 6.3 R
19.5 6.9 O
20.5 6.5 B
21.5 6.1 B
22.5 6.1 B
22.5 6.8 M
24.5 6.7 Ba
25.5 6.8 O
25.5 6.2 B
27.5 6.3 M
27.5 6.6 Ba
27.5 6.5 Nt
28 6.2 Hu
28 6.8 S
28 6.9 V
28.5 6.2 M
28.5 6.5 O
28.5 6.6 Ba
29.5 6.3 O
29.5 6.6 Ba
29.5 6.2 M
30 6.1 B
30.5 6.5 O
10 4.5 6.5 O
4.5 6.5 Nt
6 6.4 S

154539
V Cor. Bor.
9 7 9.8 M

154536
X Cor. Bor.
9 2 11.7 Ba

154615
R Serpentis
9 4 12.3 E
29 10.7 M

VARIABLE STAR OBSERVATIONS Sept.-Oct., 1915—Continued.

155847
X Herculis
Mo. Day Est. Obs.
9 30 6.8 Nt
10 4 6.6 Nt

155823
RZ Scorpii
8 31 10.0 L
9 8 9.8 L

160021
Z Scorpii
9 2 10.8 Bu

160210
U Serpentis
9 2 10.8 Bu
7 11.2 E

160221
X Scorpii
9 2 11.3 Bu

160519
W Scorpii
9 2 11.4 Bu

160625
RU Herculis
9 14 12.0 Hu
25 12.2 B

161138
W Cor. Bor.
9 2 11.4 Bu
6 11.7 B
7 11.0 E
27 12.0 Ba
29 12.2 M

162112
V Ophiuchi
8 23 8.8 R
24 8.9 R
25 8.7 R
28 9.1 R
29 9.0 R
31 9.5 L
9 2 9.4 Bu
3 8.7 R
4 8.8 R
5 8.7 R
6 9.0 R
12 8.7 R
14 9.0 R

162119
U Herculis
8 23 10.3 R
24 10.4 R
25 10.5 R
28 10.5 R
29 10.6 R

U Herculis
Mo. Day Est. Obs.
9 2 10.8 Bu
3 11.1 R
4 11.2 R
4 10.2 E
5 10.8 R
5 10.3 M
6 10.7 R
6 10.1 B
12 11.3 R
14 10.4 Hu
24 10.7 Ba
28 10.7 B
10 4 11.0 Nt

162807
SS Herculis
8 31 10.0 L
9 2 9.9 Ba
2 10.5 Bu
6 10.0 B
8 10.5 L
12 10.9 V
27 12.3 Ba
27 12.2 B
28 12.2 Y

163137
W Herculis
9 6 10.5 B
7 11.1 M
10 11.0 O
10 10.5 Pi
10 10.5 Hu
24 11.5 Ba
28 12.0 B
28 12.4 Y

123172
R Urs. Min.
8 23 10.0 R
24 9.8 R
25 10.6 R
28 10.2 R
29 9.4 R
9 2 10.2 Bu
3 9.5 R
4 9.5 R
5 9.4 R
6 10.0 R
7 10.4 M
7 9.7 E
12 9.9 R
14 9.4 R
15 9.4 R
16 9.4 R
17 9.5 R
18 9.5 R
22 9.5 M
24 9.3 Ba
27 9.1 B
29 9.5 O

163266
R Draconis
Mo. Day Est. Obs.
8 23 7.8 R
24 7.9 R
25 7.6 R
28 7.8 R
29 7.6 R
9 2 8.2 Bu
3 8.1 R
4 8.1 R
5 8.1 R
6 8.0 R
7 8.3 M
7 8.2 E
9 8.7 O
12 8.0 R
12 8.8 O
14 8.1 R
15 8.2 R
16 8.3 R
17 8.3 R
18 8.5 R
19 8.8 O
22 8.9 M
24 9.0 Ba
25 8.9 B
25 9.2 O

164055
S Draconis
8 23 8.1 R
24 8.1 R
25 8.1 R
28 8.3 R
29 8.4 R
9 3 8.5 R
2 9.8 Bu
4 8.7 R
5 8.0 R
6 8.6 R
12 8.6 R
14 8.5 R
15 9.1 R
16 9.3 R
17 9.3 R
18 9.5 R

164319
RR Ophiuchi
9 2 10.6? Bu

164715
S Herculis
8 23 10.4 R
24 10.4 R
25 10.3 R
28 10.3 R
29 10.6 R
9 2 10.6 Bu
3 10.6 R
4 10.8 R
4 10.6 Bu
5 10.9 R

S Herculis
Mo. Day Est. Obs.
9 6 10.6 B
6 11.0 R
7 10.4 M
12 11.0 R
27 11.3 Ba
27 11.3 B

165631
RV Herculis
9 2 12.0 Ba
5 12.4 M
6 12.0 B
7 12.4 E

170215
R Ophiuchi
8 28 10.4 R
29 10.5 R
9 2 10.0 Bu
3 10.8 R
4 10.9 R
5 11.0 R

170627
RT Herculis
9 2 10.4 Bu
6 10.6 B
27 11.9 Ba
28 12.1 Ba
28 12.5 Y

171333
u Herculis
8 23 4.7 R
24 5.0 R
25 4.7 R
26 4.7 R
28 4.5 R
29 4.9 R
30 4.7 R
31 4.8 R
9 3 4.6 R
4 4.5 R
5 4.8 R
6 4.7 R
7 4.7 R
8 4.8 R
11 4.7 R
12 4.8 R
14 4.5 R
15 4.8 R
16 4.8 R
17 4.6 R
18 4.8 R

171401
Z Ophiuchi
9 3 10.8 Bu

171723
RS Herculis
Mo. Day Est. Obs.
8 31 9.5 L
9 3 9.4 Bu
6 9.1 B
7 8.8 M
10 9.3 Pi
12 8.5 V
14 8.9 Hu
16 8.7 L
27 8.2 Ba
28 8.4 V
29 8.0 B

172809
RU Ophiuchi
8 31 12.4 B
9 4 11.6 E
8 11.7 M
28 10.6 V

175111
RT Ophiuchi
9 8 11.0 M

175458
T Draconis
8 28 10.1 R
29 10.2 R
9 3 10.6 R
3 10.0 Bu
4 10.7 R
5 10.1 R
6 10.0 R
7 9.6 M
12 9.9 R
12 10.2 V
14 10.0 R
15 10.1 R
16 10.5 R
17 10.1 R
18 10.0 R
28 9.7 Ba
28 9.9 Y
28 10.3 V

175519
RY Herculis
9 4 13.4 E
6 13.5 B
14 13.5 Hu

180531
T Herculis
8 23 7.9 R
24 7.9 R
25 7.7 R
28 7.6 R
29 7.6 R
9 3 7.9 R
3 7.8 Bu
4 7.8 R
5 8.6 M

VARIABLE STAR OBSERVATIONS Sept.-Oct., 1915—Continued.

T Herculis

Mo.	Day	Est.	Obs.
9	5	7.8	R
	6	7.6	R
	10	8.8	O
	10	8.5	Pi
	12	8.8	R
	14	8.6	Hu
	14	8.7	R
	15	8.9	R
	16	9.1	R
	17	9.1	R
	18	9.3	R
	21	8.9	B
	29	9.5	O
10	6	9.6	O

180565
W Draconis

9	7	11.8	M

180666
X Draconis

9	8	10.0	M

181136
W Lyrae

8	23	8.2	R
	24	8.2	R
	25	8.2	R
	28	8.1	R
	29	8.1	R
9	3	9.2	Bu
	3	8.4	R
	4	8.5	R
	5	8.5	R
	6	8.8	R
	8	9.1	M
	9	9.2	O
	12	9.3	R
	14	9.7	R
	15	10.0	R
	16	9.5	R
	17	10.0	R
	18	10.0	R
	19	9.5	O
	22	9.9	M
	27	10.5	Ba
	27	10.1	B

182224
SV Herculis

9	29	12.1	B

183225
RZ Herculis

9	3	10.8	Bu

183308
X Ophiuchi

8	23	7.9	R
	24	7.9	R
	25	8.0	R
	28	7.9	R
	29	7.8	R
	29	7.3	L

X Ophiuchi

Mo.	Day	Est.	Obs.
9	3	8.1	R
	3	7.0	Bu
	4	7.9	R
	5	7.9	R
	6	8.0	R
	12	7.6	R
	12	6.9	V
	14	7.6	R
	15	7.6	R
	16	7.5	R
	16	6.7	L
	17	7.4	R
	18	7.4	R
	27	6.8	Ba
	29	6.8	V

184205
R Scuti

8	23.7	5.1	R
	24.7	5.1	R
	25.7	4.5	R
	27	5.1	L
	27.6	6.0	Mu
	28.7	5.3	R
	28.6	5.9	Mu
	29.7	5.2	R
	29.7	6.1	Mu
	30.6	5.9	Mu
	31.7	6.0	Mu
9	1.7	6.1	Mu
	2.5	5.6	Ba
	2.7	5.9	Mu
	3.5	5.6	Bu
	3.6	5.6	R
	3.7	5.9	Mu
	4.6	6.1	Mu
	4.6	5.4	R
	5.6	5.4	R
	6	5.3	L
	6.6	5.1	R
	8.5	5.4	Pi
	9.6	6.2	Mu
	10.5	6.0	O
	12.5	5.9	O
	12.6	5.1	R
	12.7	5.9	Mu
	13.7	6.1	Mu
	14.5	6.0	O
	14.6	5.5	R
	14.7	6.1	Mu
	15.6	5.4	R
	15.6	5.5	M
	15.7	6.4	Mu
	16	5.6	L
	16.6	5.7	R
	17.6	5.5	R
	18.6	5.5	R
	22.5	5.9	M
	24.5	6.0	Ba
	25.5	6.1	O

R Scuti

Mo.	Day	Est.	Obs.
9	27.5	6.4	Ba
	27.5	6.1	Pi
	28.5	6.6	Ba
	28.5	6.3	O
	29.5	6.6	Ba
10	4.5	7.3	O
	6.5	7.4	O

184633
β Lyrae

8	23.7	4.0	R
	24.7	3.7	R
	25.7	3.4	R
	26.7	3.4	R
	28.7	4.2	R
	29.7	4.1	R
	30.7	3.8	R
	31.6	3.4	R
9	3.7	3.6	R
	4.7	4.0	R
	5.6	3.8	R
	6.6	3.4	R
	7.6	3.6	R
	8.7	3.6	R
	9.7	3.6	R
	11.6	4.1	R
	12.6	3.7	R
	14.7	3.5	R
	15.6	3.7	R
	16.7	4.0	R
	17.6	3.7	R
	18.7	3.9	R

185243
R Lyrae

8	23	4.2	R
	24	4.0	R
	25	4.1	R
	26	4.2	R
	28	4.2	R
	29	4.4	R
	30	4.0	R
	31	4.2	R
9	3	4.2	R
	4	4.4	R
	5	4.4	R
	6	4.3	R
	7	4.3	R
	8	4.2	R
	11	4.2	R
	12	4.3	R
	14	4.1	R
	15	4.0	R
	16	4.1	R
	17	4.1	R
	18	4.0	R

190108
R Aquilae

8	29	6.8	L
9	2	6.8	B
	3	6.9	Ba

R Aquilae

Mo.	Day	Est.	Obs.
9	11	6.5	B
	16	6.3	L
	27	6.4	M
	28	6.3	Ba

190926
X Lyrae

8	23	9.7	R
	24	9.7	R
	25	9.6	R
	28	9.5	R
	29	9.6	R
9	3	9.7	R
	4	9.7	R
	5	9.4	R
	6	9.5	R
	12	9.4	R
	12	9.8	Bu
	14	9.3	R
	15	9.2	R
	16	9.1	R
	17	8.8	R
	18	9.1	R

191019
R Sagittarii

9	10	8.4	Pi
	12	8.3	Bu

191033
RY Sagittarii

8	28	6.7	R
	29	6.6	R
9	3	6.6	R
	4	6.7	R
	5	6.8	R
	6	6.8	R
	12	6.6	Bu
	12	6.8	R
	14	6.7	R
	15	6.7	R

191637
U Lyrae

9	27	12.2	Ba

193311
RT Aquilae

9	4	11.0	L
	14	11.0	O
	27	12.0	Ba

193449
R Cygni

8	23	10.6	R
	24	10.8	R
	25	10.4	R
	28	10.5	R
	29	10.5	R
9	3	10.9	R
	4	10.9	R
	5	11.0	R
	6	11.0	R
	10	9.8	M

R Cygni

Mo.	Day	Est.	Obs.
9	12	11.1	R
	14	11.0	R
	15	11.2	R
	16	11.1	R
	17	11.2	R
	18	11.3	R
	24	10.0	M
	27	9.5	Ba
	28	9.2	Hu

193509
RV Aquilae

9	10	9.9	O
	12	9.5	Bu
	14	9.7	O
	25	9.9	O
	28	9.9	Ba
	29	9.8	O

193732
TT Cygni

8	23	8.1	R
	24	8.0	R
	25	7.9	R
	28	7.8	R
	29	7.8	R
9	3	7.8	R
	4	7.7	R
	5	7.7	R
	6	7.8	R
	10	8.8	M
	12	8.8	Bu
	12	7.5	R
	14	7.9	Hu
	14	7.4	R
	15	7.5	R
	16	7.6	R
	17	7.5	R
	18	7.5	R

194048
RT Cygni

9	2	9.6	Sp
	10	9.5	M
	12	10.0	Bu
	24	8.5	M
	27	7.8	Ba
	28	7.3	Hu
10	6	8.0	S

194604
X Aquilae

9	29	13.2	B

194632
χ Cygni

9	7	12.4	E
	14	11.7	M
	27	11.1	Ba
	28	10.5	Hu
	29	11.2	M

VARIABLE STAR OBSERVATIONS Sept.-Oct., 1915—Continued.

194700
η Aquilae

Mo.	Day	Est.	Obs.
8	24.7	4.0	R
	25.7	3.9	R
	26.7	4.3	R
	28.7	4.8	R
	29.7	4.6	R
	30.7	3.6	R
	31.6	3.8	R
9	3.7	4.2	R
	4.7	4.8	R
	5.7	4.3	R
	6.7	3.9	R
	7.6	3.9	R
	8.7	3.8	R
	9.7	4.2	R
	11.6	4.5	R
	12.7	4.6	R
	14.7	4.0	R
	15.7	3.9	R
	16.7	3.8	R
	17.7	4.5	R

195116
S Sagittae

8	25.7	6.0	R
	27.6	5.7	Mu
	28.6	5.9	Mu
	28.7	5.7	R
	29.7	6.1	R
	29.7	6.0	Mu
	30.6	5.8	Mu
	31.7	5.4	Mu
9	1.7	5.5	Mu
	2.7	5.6	Mu
	3.7	5.6	R
	4.6	5.7	Mu
	4.7	5.8	R
	5.7	6.2	R
	5.7	6.0	Mu
	6.7	6.2	R
	9.5	5.5	O
	9.6	5.5	Mu
	10.5	5.4	O
	12.5	5.5	O
	12.7	6.6	R
	12.7	5.6	Mu
	13.7	5.7	Mu
	14.5	5.8	O
	14.7	5.9	R
	14.7	5.8	Mu
	15.5	5.8	O
	15.7	6.3	R
	15.7	5.9	Mu
	16.7	6.3	R
	17.7	5.7	R
	18.7	5.7	R
	19.5	5.4	O
	25.5	6.8	O
	28.5	5.4	O
	29.5	5.4	O
	30.5	5.7	O

S Sagittae

Mo.	Day	Est	Obs.
10	4.5	5.7	O
	6.5	5.4	O

195849
Z Cygni

9	2	12.5	Sp
	9	12.4	Sp
	10	12.5	Sp
	28	12.5	Ba

200212
SY Aquilae

9	2	12.2	B
	28	12.5	Ba
	30	13.0	B

200647
SV Cygni

8	23	9.5	R
	24	9.4	R
	25	9.2	R
	28	9.4	R
	29	9.4	R
9	3	9.8	R
	4	9.2	R
	5	9.1	R
	6	9.1	R
	10	9.1	M
	12	9.1	R
	14	8.4	R
	15	8.6	R
	15	8.2	Hu
	16	8.7	R
	17	8.6	R
	18	8.7	R

200715a
S Aquilae

8	28	10.2	R
	29	10.7	R
9	2	10.9	B
	3	10.8	R
	4	10.9	R
	5	10.6	R
	6	11.0	R
	10	8.7	M
	12	10.9	R
	14	11.0	R
	15	11.1	R
	16	11.2	R
	22	11.0	B

200715 b
RW Aquilae

8	24	8.9	R
	25	8.8	R
	28	8.8	R
	29	8.6	R
9	3	8.8	R
	4	8.6	R
	5	8.8	R
	6	8.6	R

RW Xquilae

Mo.	Day	Est.	Obs.
9	10	8.8	M
	12	8.7	R
	14	8.8	R
	15	9.0	R
	16	8.9	R
	17	8.8	R
	18	9.0	R

200812
RU Aquilae

9	2	12.1	B
	28	10.0	Ba
	30	9.9	B
	30	10.2	O

200822
W Capricorni

9	28	10.7	M

200916
R Sagittae

8	24	8.8	R
	25	8.9	R
	28	9.1	R
	29	9.1	R
9	3	9.3	R
	4	9.3	R
	5	9.3	R
	6	9.4	R
	10	8.8	M
	12	9.3	R
	14	9.0	R
	15	9.2	R
	16	9.1	R
	17	9.2	R
	18	8.9	R

200906
Z Aquilae

9	2	12.0	B
	30	13.4	B

200938
RS Cygni

8	23	8.9	R
	24	8.8	R
	25	8.9	R
	28	9.0	R
	29	8.9	R
9	1	8.9	M
	3	9.0	R
	4	8.8	R
	5	8.8	R
	6	8.8	R
	10	8.7	M
	12	8.9	R
	14	8.7	R
	14	8.8	L
	15	8.7	R
	16	8.7	R
	17	9.1	R
	18	8.8	R

201008
R Delphini

Mo	Day	Est.	Obs.
9	2	11.1	B
	22	12.0	B
	28	12.1	Ba

201121
RT Capricorni

8	28	8.3	R
	29	7.9	R
9	3	7.7	R
	4	7.6	R
	5	7.6	R
	6	8.2	R
	12	8.2	R
	14	7.9	R
	15	7.6	Ho
	15	8.1	R
	16	7.2	L
	16	8.1	R
	28	8.0	M

201647
U Cygni

8	23	11.5	R
	24	10.9	R
	25	10.7	R
	28	11.2	R
	29	11.0	R
9	3	11.1	R
	4	11.1	R
	5	11.1	R
	6	11.3	R
	10	8.9	M
	12	10.1	R
	14	8.7	M
	14	9.5	L
	14	10.2	R
	15	10.2	R
	16	10.1	R
	17	10.2	R
	18	10.3	R

202539
RW Cygni

8	23	9.4	R
	24	9.4	R
	25	9.4	R
	28	9.3	R
	29	9.3	R
9	1	9.1	M
	3	9.4	R
	5	9.5	R
	6	9.6	R
	10	9.3	M
	10	9.0	Pi
	12	9.7	R
	14	9.7	R
	15	9.7	R
	16	9.9	R
	17	9.8	R
	18	9.8	R
	24	9.2	M

202817
Z Delphini

Mo	Day	Est.	Obs.
9	12	9.1	V
	27	9.9	Pi
	28	9.9	Ba
	28	10.1	V

202946
SZ Cygni

8	23	8.8	R
	24	8.7	R
	25	9.8	R
	28	9.9	R
	29	9.2	R
9	1	9.6	M
	2	9.4	Ba
	3	9.2	R
	4	9.1	R
	5	9.0	R
	6	8.9	R
	10	9.6	M
	12	9.0	R
	14	9.9	R
	15	9.9	R
	16	10.3	R
	17	10.2	R
	18	9.9	R
	24	9.1	Ba
	25	8.9	Ba
	27	9.1	Ba
	28	9.3	Ba
	28	9.6	Hu
	29	9.6	Ba

202954
ST Cygni

9	10	11.4	M
	24	10.3	M

203611
Y Delphini

8	31	10.9	B
9	28	11.1	Y
	28	11.8	Ba
	29	11.5	B

203816
S Delphini

9	5	11.6	M
	28	11.5	Y

203847
V Cygni

9	10	9.6	M
	24	9.2	M
	28	8.6	Ba

204016
T Delphini

9	5	10.0	M
	27	10.3	M
	27	10.3	Pi
	28	10.4	Ba
	28	10.8	Y

VARIABLE STAR OBSERVATIONS Sept.-Oct., 1915,—Continued.

204318
V Delphini

Mo.	Day	Est.	Obs.
9	28	12.4	Ba

204405
T Aquarii

Mo.	Day	Est.	Obs.
8	28	8.3	R
	29	8.5	R
9	2	7.6	B
	3	8.3	R
	4	8.4	R
	5	8.3	R
	6	8.0	R
	12	8.4	R
	14	7.5	R
	15	7.5	R
	15	7.5	M
	15	7.6	Ho
	16	7.5	R
	17	7.3	R
	28	7.3	Ba
	29	7.5	B

204846
RZ Cygni

Mo.	Day	Est.	Obs.
9	24	9.9	M
	29	11.0	Ba

205017
X Delphini

Mo.	Day	Est.	Obs.
9	2	9.3	B
	29	9.7	Ba
	29	10.0	B

205923
R Vulpeculae

Mo.	Day	Est.	Obs.
8	23	9.4	R
	29	9.7	R
9	3	9.9	R
	4	10.1	R
	5	10.3	R
	6	10.5	R
	12	10.8	R
	29	12.5	Ba

210119
TW Cygni

Mo.	Day	Est.	Obs.
9	12	10.9	V
	29	11.0	V
	29	11.2	Ba

210116
RS Capricorni

Mo.	Day	Est.	Obs.
8	28	8.7	R
	29	8.6	R
9	3	8.4	R
	4	8.3	R
	5	8.3	R
	5	8.0	M
	6	8.2	R
	8	8.0	Ho
	10	7.8	M
	12	8.2	R
	14	8.4	R
	15	8.3	R
	16	8.4	R
	17	8.1	R

210865
T Cephei

Mo.	Day	Est.	Obs.
8	23	8.1	R
	24	8.3	R
	25	8.2	R
	28	8.0	R
	29	8.0	R
9	3	8.0	R
	4	7.9	R
	5	8.0	R
	6	7.8	R
	6	7.4	L
	9	8.4	O
	12	7.7	R
	14	7.7	O
	14	7.9	R
	15	7.8	R
	16	7.7	R
	16	7.5	L
	17	7.9	R
	18	7.8	R
	19	8.2	M
	29	6.9	Ba
	29	7.7	O

211614
X Pegasi

Mo.	Day	Est.	Obs.
9	29	10.7	Ba
	30	10.6	O
10	6	11.2	O

213244
W Cygni

Mo.	Day	Est.	Obs.
8	20	5.6	L
	23	6.0	R
	24	6.1	R
	25	5.7	L
	25	6.1	R
	27	5.6	L
	28	6.2	R
	29	6.2	R
	29	5.5	L
	31	5.7	L
9	3	6.2	R
	4	6.1	R
	5	6.0	R
	6	6.1	R
	6	5.6	L
	12	6.1	R
	14	6.0	R
	15	6.0	R
	16	5.7	L
	16	6.1	R
	17	6.1	R
	18	6.2	R

213678
S Cephei

Mo.	Day	Est.	Obs.
9	19	10.8	M
	29	10.0	Ba
10	6	10.0	S

213753
RU Cygni

Mo.	Day	Est.	Obs.
9	5	8.8	M
	14	8.6	M

213843
SS Cygni

Mo.	Day	Est.	Obs.
8	20	9.2	L
	23.7	8.5	R
	24.7	8.1	R
	25.7	7.9	R
	25	8.1	L
	27	8.2	L
	27.7	8.3	E
	28.7	8.3	R
	29.7	8.8	R
	29	8.1	L
	31	8.2	L
	31.5	8.8	B
9	1.5	8.7	M
	1.7	8.4	E
	2.5	9.0	B
	2.5	9.2	Ba
	3.5	9.4	B
	3.7	8.9	Sp
	3.7	9.1	R
	4	9.8	L
	4.5	9.7	B
	4.6	9.8	E
	4.7	9.7	R
	5.5	10.2	M
	5.7	9.9	R
	5	10.0	L
	6.0	10.2	R
	6.6	10.4	R
	6.5	10.5	B
	6.6	10.5	M
	6.8	10.7	E
	7.6	10.9	M
	7.6	10.7	E
	8	11.0	L
	8.6	11.2	M
	9.6	11.2	E
	10.7	11.5	E
	12	11.5	L
	12.7	11.9	Sp
	13.6	11.7	E
	14	11.5	L
	14.8	11.8	M
	15	11.6	Hu
	15.5	11.9	B
	16	11.6	L
	21.7	11.7	E
	24.5	11.6	Ba
	25.5	11.6	Ba
	27.5	11.5	Ba
	27.5	11.5	M
	27.5	11.7	Pi
	28	11.6	Hu
	28.5	11.6	M
	28.5	11.6	Ba
	29.5	11.8	Pi
	29.5	11.6	Ba
	29.5	11.8	M

213937
RV Cygni

Mo.	Day	Est.	Obs.
8	23	8.4	R
	24	8.4	R
	25	8.3	R
	28	8.3	R
	29	8.4	R
	31	7.4	L
9	1	8.3	M
	3	8.4	R
	4	8.4	R
	5	8.4	R
	6	8.4	R
	12	8.5	R
	14	6.6	L
	14	8.5	R
	15	8.5	R
	16	8.5	R
	17	8.4	R
	18	8.4	R

214024
RR Pegasi

Mo.	Day	Est.	Obs.
9	2	10.0	Sp
	4	9.7	B
	9	9.8	Sp
	14	9.9	M
	15	10.0	O
	28	10.3	O
	29	10.6	Ba

220613
Y Pegasi

Mo.	Day	Est.	Obs.
9	14	9.2	O
	28	9.3	O
	29	9.8	Ba

220714
RS Pegasi

Mo.	Day	Est.	Obs.
9	29	11.2	Y

222439
S Lacertae

Mo.	Day	Est.	Obs.
9	28	8.7	Y
	29	8.6	Ba

222557
δ Cephei

Mo.	Day	Est.	Obs.
8	23.7	3.4	R
	24.7	4.0	R
	25.7	4.1	R
	26.7	4.0	R
	28.7	3.5	R
	29.7	3.9	R
	30.7	4.0	R
	31.6	4.1	R
9	3.7	3.5	R
	4.7	3.9	R
	5.7	4.0	R
	6.0	4.2	R
	6.7	4.2	R
	7.6	3.6	R
	8.7	3.4	R
	9.7	3.8	R

δ Cephei

Mo.	Day	Est.	Obs.
9	11.6	3.4	R
	12.7	4.1	R
	14.7	3.4	R
	15.7	4.0	R
	16.7	4.3	R
	17.7	4.1	R
	18.9	3.6	R

223841
R Lacertae

Mo.	Day	Est.	Obs.
9	28	12.4	Y

225120
S Aquarii

Mo.	Day	Est.	Obs.
9	8	12.4	Ho
	29	11.7	Ba

225914
RW Pegasi

Mo.	Day	Est.	Obs.
9	10	11.6	Pi
	29	11.2	M

230110
R Pegasi

Mo.	Day	Est.	Obs.
9	10	11.0	Pi
	14	10.8	M
	28	10.6	Pi
	28	10.4	O
	29	10.7	Ba
10	4	10.5	O

230759
V Cassiop.

Mo.	Day	Est.	Obs.
9	2	9.1	Sp
	3	9.1	B
	15	8.6	Pi
	19	8.5	O
	22	8.5	B
	27	8.4	Ba
	28	8.2	Pi
	28	8.3	O
	29	8.2	Y
10	6	8.2	O

231425
W Pegasi

Mo.	Day	Est.	Obs.
9	12	9.9	V
	14	10.5	O
	14	10.0	M
	29	10.3	V
	29	10.8	Ba

231508
S Pegasi

Mo.	Day	Est.	Obs.
9	4	9.3	B
	12	10.4	O
	14	9.5	M
	14	9.4	R
	15	10.4	O
	28	11.0	O
	29	10.0	Ba

VARIABLE STAR OBSERVATIONS Sept.-Oct., 1915—Continued.

233335 ST Androm.				*233815* R Aquarii				235350 R Cassiop.				235525 Z Pegasi				235855 Y Cassiop.			
Mo.	Day	Est.	Obs.	Mo.	Day	Est.	Obs.	Mo.	Day	Est.	Obs.	Mo.	Day	Est.	Obs.	Mo.	Day	Est.	Obs.
9	15	9.5	Hu	9	6	7.2	R	9	3	11.1	B	9	28	10.1	O	9	29	12.0±	Y
	27	8.9	Ba		8	7.5	Ho		6	11.9	M		29	10.7	V				
	28	9.3	Pi		29	7.8	Ba					10	6	10.0	O				
	29	9.4	O		29	8.0	M												
	29	9.4	S																

235939 SV Androm.			
9	29	10.5	Ba
	29	10.8	Pi

Perhaps the most creditable showing we have made is in the number of variables that have been observed, two hundred and eighty-two, within eleven of the total number of charts on hand.

Mr. Richter leads in the number of observations contributed per month and for the year. Quantity in this work is of course not the desired end, but it is a means to an end, for only by constant practice in observing can we hope to attain that degree of accuracy that will render our observations reliable and valuable.

It is most gratifying to note that we are already attaining fairly dependable results, and a comparison of our work for the past four years reveals a decided advance in the quality of the observations.

We again acknowledge our debt of gratitude to Professor E. C. Pickering for his continuing interest and encouragement and to the Editor of POPULAR ASTRONOMY for the privilege granted in the monthly publication of the reports, thus greatly promoting the welfare of the Association.

The thanks of the Association are due Mr. David B. Pickering for printing and distributing many blue prints to the new members.

In conclusion, the secretary wishes to thank each member of the Association for the encouragement and support he has rendered him during the past year The spirit of good fellowship that pervades our ranks is a source of inspiration rendering service a pleasure, and our annual meetings greatly anticipated events.

WILLIAM TYLER OLCOTT,
Corresponding Sec'y.

Norwich, Conn.
Oct. 10, 1915.

Notes on Observed Sun Spots.—Between March 1, and May 24, 1915 observations of sunspots were made at the Boston University Observatory on forty-three dates. On five days no spots were visible.

The five-inch refractor was used and spots were plotted on the field of a reticulated eye-piece, power 60, the diameter of the field being about 45 minutes. Latitudes and longitudes were found by placing on the drawings transparent photographic reproductions of Thompson's disks.

Twenty-nine groups, containing one hundred and twenty-seven spots, were seen.

The distribution in longitude showed some peculiarities. Between 220° and 320° there were 16 groups with 67 spots, this region, therefore, presenting more than fifty per cent of the disturbances noted. From 0° to 100° there were 8 groups with 23 spots; from 100° to 220°, 2 groups with 12 spots; and from 320° to 360°, 3 groups with 5 spots. Between 120° and 195° there were no spots seen.

Fourteen groups with 45 spots were north of the equator; fifteen groups with 62 spots, south. There were no spots recorded within ten degrees either north or south of the equator. Between 10° and 20° north and south there were nine and eleven groups, respectively; between 20° and 30°, five groups north and four south. None were seen having a latitude more than 30°.

PRISCILLA FAIRFIELD.

ANNUAL REPORT OF THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS FOR THE YEAR ENDING OCT. 10, 1915.

RECORD OF OBSERVATIONS

	Baldwin (Bl)	Bancroft (Ba)	Barbour (Bb)	Bolfing (Bg)	Bouton (B)	Burbeck (Bu)	Craig (C)	Eaton (E)	Harrell (Ha)	Hay (Hy)	Herriott (He)	Hoge (Ho)	Hunter (Hu)	Huntington (H)	Jacobs (J)	Lacchini (L)	Leonard (Le)	Lindsley (Ly)	Mach (Ma)	McAteer (M)	Mundt (Mu)	Olcott (O)	Pickering (Pi)	Richter (R)	Spinney (Sp)	Stepka (St)	Miss Swartz (S)	Vrooman (V)	Miss Young (Y)	Additional Observatrons	Total number of Observations	Number of observers	Number of Variables Observed	Total Number of Variables Observed
Nov.	50			13	25	82	62	28		29			32	51	15	70	29	166	51	75	18	110	32	490	19		12	12	24	4	1499	24	148	
Dec.			29	48	39	46		33		108	62		33	7	11	85		191	69	157	13	109	27	624	14	11	7	12	46	3	1784	24	163	
Jan.			50	27	55	49		30		40			32		9	75		40	7	48	8	128	14	231	13		15	8	14		893	20	145	
Feb.			119		41	68		29		43			31					51	12	82	13	35	9	380	43		13	8	24		1001	17	122	
Mar.		37			69	37		6	9	35			12			64		81	15	69	6	80	26	218	23	4	14	8	33		846	20	149	
Apr.	17	37	44		110	115		30	3	64						67		51	5	204	10	68	65	355	52		13	16	35		1361	20	172	
May		118	37		37	85		7	4							22		92	11	109	12	28	56	126	34		11	15	17		821	18	122	
June		18	14		22	122		24	1							55		66	25	89	15		108	182	25		15	14	15		810	17	144	
July		64	8		28	54				114						56		35	18	82	21		10	669	14		5	8			1186	15	75	
Aug.		159			35	20		43		62						60		46	24	84	25	23	46	813	13			23		9	1485	15	153	
Sept.		224			57			51								67			52	105	29	58	26	**820**	48			23			1560	12	160	
Oct.		85			84	42		34				21	22			76				146	30	90	42	637	34		8	22	16	9	1398	16	179	
Total	67	742	301	88	602	720	62	315	17	495	62	21	162	58	35	697	29	819	289	1250	200	729	461	**5545**	332	15	113	169	224	25	**14644**			282

ANNUAL RECORD OF THE ASSOCIATION.

Year	Number of Observers	No. of stars Observed	Number of Observations	Total
1912	19	175	6180	
1913	20	200	12914	
1914	28	255	14506	
1915	30	282	14644	**48244**

A Vanished Star? The Supposed Disappearance of the Companion to Alpha Cancri.—The note in POPULAR ASTRONOMY, Volume XXIII, page 530, was naturally of much interest to me, for on many occasions the inability of an observer to see the fainter component of a double star has given rise to the suspicion that the companion is actually a variable. A variable double-star astronomers have been looking for for many years but thus far without any success. In POPULAR ASTRONOMY, Volume II, page 250, Burnham, writing of the troublesome double, H 165, says;—

"It seems still more improbable that either component should be variable to the extent of disappearing altogether. No such double star is known in the heavens. There is nothing...to give one the slightest amount of faith in the actual disappearance from the sky of any double star ever observed by any one at any time.....It is possible, of course, that this may turn out to be the long lost variable double;....if so, it will be a most interesting pair for measurement hereafter."

The discordant and contradictory observations of H 165 have now been thoroughly straightened out. The system Alpha Cancri fortunately admits of no uncertainty as to the location and identification of the star, but the announcement that the companion has entirely disappeared is naturally of the highest interest.

Accordingly, in the course of my regular observing work I have looked at this star on three different nights, as follows:—

Oct. 9	1915.769	323.°9 11″.01	12.4 P 2
Oct. 11	1915.775	Companion of about 12.5 magnitude	
Oct. 12	1915.777	Companion of about 12.0 magnitude	

The pair is at this time low in the east and can only be observed for a few hours before sunrise. Unfortunately, we are here west of the city of Philadelphia, and we never attempt to measure difficult stars until they have passed west of the meridian. Consequently Alpha Cancri, being on each of the three nights observed low over the city and through all the city's lights and smoke, was seen to but very poor advantage. Never-the-less I feel perfectly safe in saying that thereis (to us) not the slightest evidence of any change whatever in the brightness or visibility of the companion. I think that the whole trouble with the French observers arises from the fact that they expected the companion to be of about the 11th magnitude, as estimated by Dembowski and Otto Struve. It is certainly much fainter than this but, in my judgement, there is no evidence of variability. My own estimate of the magnitude of this star in 1899 was 12.2. So faint a star so near a bright attendant will naturally be seen with difficulty (if at all) unless the seeing is good.

Though the magnitude of the companion appears to be entirely constant, there seems to be a very slow decrease in the angle and distance of the pair, doubtless owing to the proper motion of the brighter star.

ERIC DOOLITTLE.

The Companion to α Cancri.—Professor Barnard writes that he looked up the star α Cancri on the morning of October 6, 1915, and found the companion in its place and of the usual brightness, about 11th magnitude. Measures through clouds gave

Position Angle 324°.2 Distance 11″.24.

If the European observations referred to on page 530 of the October number of POPULAR ASTRONOMY were correct, the companion must be a variable star.

How to find Algol.—Algol, the most famous of variable stars, can easily be found by the following simple rule, the only astronomical knowledge presupposed being the ability to recognize the Pleiades and the north star.

Consider the Pleiades to be the foot of an F. Now go about one-fourth of the distance toward the Pole star, or about 18°, to a third magnitude star ϵ Persei. Notice that half way on this line and forming the middle cross piece of the F are two stars, ζ Persei and Atik, about 3° apart and of the third and fourth magnitudes

respectively. From ϵ Persei turning at right angles toward the west about 14° the top of the F, brings you to Algol, normally a second magnitude star. Drop down toward the south from Algol 2° or 3° to a fourth magnitude star ρ Persei, to complete the F. This fourth magnitude star is itself a variable. You now have the outlines of a capital F in two senses, which when once seen will stand out almost as conspicuously as the Great Dipper. So much for finding Algol. Now a rule for observing its variability. Consider the line from ϵ Persei to Algol to be one of the equal sides of an isosceles triangle. Go north the same distance to α Persei for the other side, and from α Persei back to ϵ for the base. Algol is at the apex, α and ϵ form fine comparison stars for observing the brilliancy of Algol. Normally Algol is slightly fainter than α Persei and slightly brighter than ϵ. But when Algol faints away it is not as bright as ϵ but about as bright as the small star just south of it. But here is an anomaly. Last winter upon glancing at Algol, as I usually do when everything is favorable, I was astonished to notice that Algol was decidedly brighter than α Persei. The next time I observed it, which might have been a week or two later, Algol still was brighter than α Persei but did not seem to me to be as much brighter as before. From that time until very recently I have been unable to get a satisfactory view. Now it seems almost as bright as α instead of half way between α and ϵ, as has been my standard of comparison for many years. Newcomb and Holden's Astronomy (p. 440) says Algol "is supposed to be from time to time subject to slight fluctuations." But this fluctuation was not slight. What is the answer?

It may interest some to know that Nova Persei, which I discovered independently the same night that it was discovered in Great Britain, is almost exactly at the center of this triangle formed by α, β (Algol) and ϵ Persei. It then exceeded α Persei in brilliancy, but now is seen only with powerful telescopes.

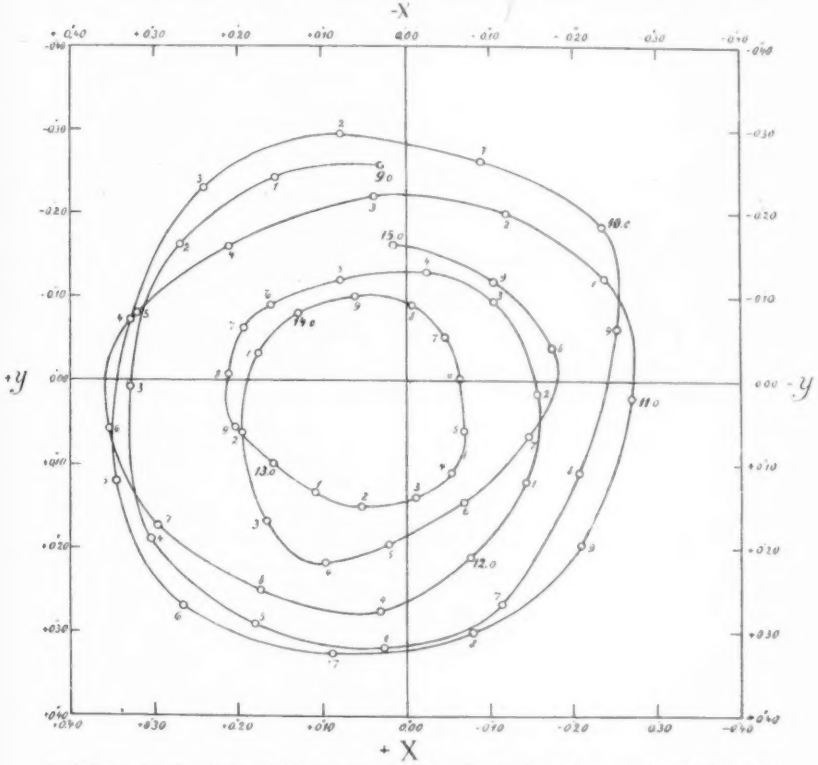
WILLIAM B. PARMELEE

GENERAL NOTES.

Professor Theodor Albrecht of the Royal Prussian Geodetic Institute died on August 31, 1915, at the age of 72 years. During the last twenty years he had devoted himself largely to the organization of the International Latitude Survey and the discussion of the results obtained at the six latitude stations on the parallel of latitude 39° 8′.

The Next Meeting of the American Astronomical Society.—The executive committee of the American Astronomical Society has accepted the invitation of Professor John A. Miller to hold the next meeting of the society at Swarthmore, Pennsylvania, in August of 1916.

The Motion of the North Pole.—The accompanying diagram, from *Astronomische Nachrichten* No. 4802, shows the wandering of the earth's north pole during the years 1909-1915, as determined by Mr. Th. Albrecht from the results obtained at the six latitude stations, Mizusawa in Japan, Tschardjui in Turkestan,



Carloforte in Sardinia, Gaithersburg, Maryland, Cincinnati, O., and Ukiah, Cal. These stations are all close to the parallel of latitude 39° 8′. It will be seen from the diagram that the wobble of the earth's axis was at a minimum in 1913 and is now widening out.

Cincinnati Observatory.—No. 18 of the Publications of the Cincinnat Observatory has just come to hand. It contains the first six hours of a new catalogue of proper motion stars. Professor Porter says in the preface, "The chief purpose of this catalogue being to furnish proper motions whose uncertainty shall be a small fraction of the total motion, it was necessary to place the lower limit

rather high.....For some investigations, of course, a more general knowledge of the smaller motions is desirable; but at the same time it seems to me a proceeding of doubtful validity to employ a great mass of data for which the probable error is nearly as great as the value itself. If we hope to solve the problems connected with stellar movements, we must winnow our material so that it shall consist only of motions that may be supposed to have a reasonably small percentage of error. We offer this catalogue as affording such data for the fainter stars. Taken in connection with Boss' catalogue it may be regarded as presenting a fairly complete view of stars with well-determined motions."

The remainder of the work is well advanced and it is proposed to issue an installment each successive year until completed.

Ten Years Work of a Mountain Observatory.—This is a 100 page pamphlet, gotten out by the Carnegie Institution of Washington as Publication No. 235. In it Professor George E. Hale gives a brief account of the development and work of the Mount Wilson Solar Observatory. It is printed entirely on fine plate paper and illustrated on almost every page with most excellent cuts, illustrating the building, apparatus and astronomical results obtained in the past ten years. Professor Hale uses as popular language as is possible under the circumstances and gives the general reader a very comprehensive view of the various lines of investigation, the difficulties encountered in pursuing them and the marvelous results already obtained in several instances.

We note that the steel ribs of the dome for the 100-inch reflector were partly in place in June 1915. This dome will be 100 feet in diameter. It is not expected that the telescope will be ready for use before 1916. The larger parts for the mounting are now under construction at the Fore River Ship Yard in Quincy, Massachusetts, where machinery used for building the largest battleships is available. The smaller parts of the mounting and others requiring special accuracy of fitting are being made in the observatory machine shop in Pasadena.

Star and Weather Gossip.—This is the title of a delightful little book by Mr. Joseph H. Elgie, at 24 St. Michael's Road, London, S. W., England. The book is a collection of brief sketches on a great variety of topics, perhaps two-thirds of them astronomical, all easy to read and very interestingly written. You can take this book up at leisure moments, five minutes at a time, finishing one or two sketches in that length of time. The sketches are all disconnected, so that the book may be opened at almost any page and read with pleasure.

The book is published by the author at the above address. Price 2 shilling 6 pence, net.

THE HUNTER'S MOON.

Like gorgeous pearl amid the dome of night,
Whose sun-lit splendor shames the stars from sight
And charms the eye with soft, unsullied light,
A full October moon begins to rise
O'er wooded knoll where frost has wrought its blight,
O'er meadow sear which lies so wierd and white,
O'er valley's depth or mountain's dizzy height,
Till Earth becomes akin to paradise!

CHARLES NEVERS HOLMES.